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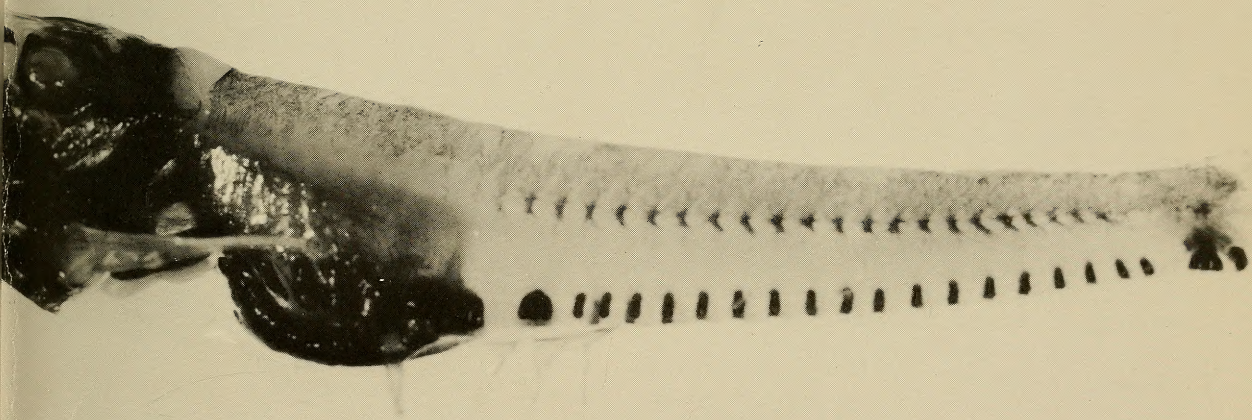

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Most back numbers of this journal and its predecessors, *Transactions of The Ottawa Field-Naturalists' Club*, 1879-1886, and *The Ottawa Naturalist*, 1887-1919, and *Transactions of The Ottawa Field-Naturalists' Club and The Ottawa Naturalist — Index* compiled by John M. Gillett, may be purchased from the Business Manager.

Cover: The Bottlelight, *Danaphos oculatus* (Garman) captured from the research vessel *Parizeau* off the Brooks Peninsula, November 1983. British Columbia Provincial Museum photograph C-16: 11069 taken by Brent Cooke. *See* Peden and Hughes pp. 1-9.

The Canadian Field-Naturalist

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First Records, Confirmatory Records, and Range Extensions of Marine Fishes off Canada's West Coast

ALEX E. PEDEN and GRANT W. HUGHES

Aquatic Zoology Division, British Columbia Provincial Museum, Victoria, British Columbia V8V 1X4

Peden, Alex E., and Grant W. Hughes. 1986. First records, confirmatory records, and range extensions of marine fishes off Canada's west coast. Canadian Field-Naturalist 100(1): 1–9.

First records of *Danaphos oculatus* (Sternoptychidae), *Neoscopelus macrolepidotus* (Neoscopelidae), *Notoscopelus japonicus, Lampadena urophaos, Protomyctophum crockeri* (Myctophidae), *Benthodesmus tenuis* (Trichiuridae), *Seriphus politus* (Sciaenidae), and *Spectrunculus grandis* (Bythitidae) are described for British Columbia. Confirmatory records of *Ichthyococcus elongatus* (Photichthyidae), *Ceratoscopelus townsendi* (Myctophidae), *Icelus spiniger* (Cottidae) are discussed. Additional records for *Cyclothone signata, C. pseudopallida* (Gonostomatidae), *Genyonemus lineatus* (Sciaenidae), and *Aphanopus carbo* (Trichiuridae), are listed. Extensions of known ranges within British Columbia are noted for *Amphistichus rhodoterus* and *Hyperprosopon ellipticum* (Embiotocidae).

Key Words: North Pacific, British Columbia, Gonostomatidae, Sternoptychidae, Myctophidae, Trichiuridae, Sciaenidae, Bythitidae, Photichthyidae, Cottidae and Embiotocidae.

Since the last publication describing the marine fish fauna of British Columbia (Hart 1973), at least 62 additional species of fishes have been found within Canada's 200 nautical mile fishing zone and the known fauna now includes a total of 387 species. Jean et al. (1982) briefly list a number of these new records for western Canada. In order to substantiate their records more fully, many of these records are described here in detail in addition to some species records listed by Aron (1960) but not recognized by recent authors (Clemens and Wilby 1961; Hart 1973; Jean et al. 1982). Other significant records found on cruises of the research vessel *Parizeau* are also reported below.

Some authorities have suggested that many new records which represent strays do not deserve attention as significant elements of the Canadian fauna. However, so little attention has been given in the past to the majority of non-economic species off British Columbia because of gear selectivity or limited objectives of researchers, that the true patterns of distribution, abundance or seasonality of occurrence have not always been apparent from the literature. Unless otherwise mentioned, methods of counts and measurements follow the techniques of Hubbs and Lagler (1958). Code for photophores in myctophids is taken from Wisner (1974). Acronyms for British Columbia Provincial Museum (BCPM), National Museums of Canada (NMC), Oregon State University (OSU) and University of Washington (UW) are used in the designation of collection numbers.

GONOSTOMATIDAE

***Cyclothone signata* Garman Showy Bristlemouth**

Although originally recorded off southern British Columbia only once (Peden 1975), this species was also taken much earlier by Aron (1960) in "Brown Bear" cruise 202, haul 11, 49°59′N, 130°47′W, ≦400 m (non-closing I.K. trawl) as gonostomid larvae or post-larvae of 24–28 mm total length (T.L.). One specimen available to us from this sample measures 25 mm standard length (S.L.) (possibly 28 mm T.L.) and since the species does not grow to a large size (≦ 32.5 mm S.L., Mukhacheva 1964) it is not surprising that the species was grouped by Aron amongst unidentified postlarval material.

A second specimen, 35.7 mm S.L., from "Brown Bear" cruise 202, haul 15, 49°50′N, 133°20′W, ≦ 400 m was probably listed by Aron amongst "3 specimens of *C. microdon*? (bad shape) about 40" mm T.L. Because the species does not have scales it would seem reasonable for the original investigators to assume they had captured a descaled *C. microdon* (=*C. pacifica*).

A third specimen, 37.7 mm S.L., [larger than Mukhacheva's (1964) record] was taken in "Brown Bear" cruise 202, haul 19, 49°53′N, 135°23′W, ≦ 400 m depths and recorded by Aron as "*C. microdon*"?

about 40 mm T.L. Recently in a year of El Nino (1983) we captured at least two dozen specimens off the Brooks Peninsula while aboard the CCGS *Parizeau.*

Basic counts and measurements for the Aron specimens are [counts given by Mukhacheva (1964) in parenthesis]: dorsal rays 12–14 (12–14), anal rays 18–19 (17–20), pectoral rays damaged (9–10), gill rakers 8–9 + 1 + 3–4 = 12–14 (4 + 1 + 9 = 14), branchiostegal photophores 9 (9), VAV photophores 4 (4), OA photophores damaged (7), AC photophores 8-12, some lost? (13–14). The species is further identifiable by having no teeth on vomer, all the VAV photophores evenly spaced, and being pale coloured with vertical bars of dark pigment visible under body musculature and between branchiostegal photophores.

***Cyclothone pseudopallida* Mukhacheva** **Phantom Bristlemouth**

We have a specimen 40.9 mm S.L. recorded by Aron (1960) as "*C. microdon*? (bad shape) about 40 mm T.L." from "Brown Bear" Cruise 202, haul 15, 49°50′N, 133°20′W, ≦ 400 m water depths. The species was previously referred to as *Cyclothone* sp. Berry and Perkins (see Peden et al. *in press*) and thus Aron's specimen represents the second documented record for Canada'a territorial fishing zone. Counts are [those of Muchacheva (1964) in parenthesis]: — dorsal rays 13 (12–14), anal rays 18 (17–20), pectoral rays damaged (9–10), gill rakers 11 + 2 + 6 = 19(11 - 12 + 2 + 5 - 6 = 18–20), branchiostegal photophores 11 (10), OA photophores 8 (8), VAV photophores 5 (4–5), and AC photophores 15 (14–15). The species is also identifiable by the proximity of the anus to the pelvic fins rather than to the anal fin and the first two VAV photophores being closer together than remaining VAV photophores.

STERNOPTYCHIDAE

***Danaphos oculatus* (Garman)** **Bottlelight**

Two specimens of *Danaphos oculatus* 33 and 35 mm S.L. were captured from the *Parizeau*, off the Brooks Peninsula: BCPM 983–1653, 50°00′N, 128°19.2′W, 325 m, 22 November 1983 and BCPM 983–1650, 50°07.8′N, 128°18.1′W, approximately 0 to 500 m, 21 November 1983.

It is readily distinguished by its shape and photophore pattern. One specimen (BCPM 983–1653) possesses 3 small crowded photophores anteriorly plus 16 well-spaced photophores posteriorly over the anal fin; 4 crowded plus 1 spaced photophore at base of tail, 5 large pairs between the pelvic and anal fins, 7 evenly spaced ones on midlateral side of abdomen behind the pectoral base, 4 large photophores on isthmus, 11 between gill isthmus and base of pelvic fins plus 6 along the branchiostegal membranes, dorsal rays 6, anal rays, 24.

As the species has been recorded as far north as Oregon (Miller and Lea 1972), our specimens represent the first verifiable records off British Columbia and the northernmost record for the Pacific coast of North America.

PHOTICHTHYIDAE

***Ichthyococcus elongatus* Imai** **Slim Lightfish**

Mukhacheva (1980) reports a specimen off Vancouver Island although his distribution map illustrates it off the Queen Charlotte Islands. Because this reference is rather inaccessible due to its Soviet origin, it is noted here for Canadian readers. The specimen is reported as USSR Academy of Sciences (Leningrad) No. 37951 (near Vancouver Island, depth 350 m, length 102.5 mm). The species ranges from off southern Japan and Mukhacheva suggests the Canadian and a Californian record result from dispersal via the North Pacific drift and the Alaska and California currents.

NEOSCOPELIDAE

***Neoscopelus macrolepidotus* Johnson** **Glowingfish**

A specimen (see Jean et al. 1982) was received by the Pacific Biological Station, and presented to the British Columbia Provincial Museum (BCPM 979–11145). This 144 mm S.L. specimen (Figure 1) was probably captured off the Queen Charlotte Islands in nonclosing gear that descended to 370 fm (≦ 688 m). The species can be distinguished from other fishes in the northeastern Pacific Ocean by its general appearance, and the pattern of rows of very large ventral photophores (see Nafpaktitis 1977).

N. macrolepidotus is a benthopelagic species occurring over continental and island slopes not far from the bottom at depths approximately between 300 and 800 m (Nafpaktitis 1977).

Counts of the specimen are:

Dorsal rays 11, anal rays 10, pectoral rays 18, vertebrae 31, gill rakers 2 + 1 + 8, total gill rakers 11, LO photophores (see Nafpaktitus 1977, for code) 13, PVO photophores 3, BP photophores 2, PO photophores 10, AV photophores 10, IS photophores 8, AVO photophores 8, AVO photophores 3, AM photophores (19(+ 1?), CAC photophores 2 + 2 + 3?, VC photophores 21, PM photophores 4, TO photophores present.

MYCTOPHIDAE

***Ceratoscopelus townsendi* (Eigenmann and Eigenmann)** **Dogtooth Lanternfish**

Ceratoscopelus townsendi was omitted from the list of fishes off British Columbia by Jean et al. (1982) because major publications on this fauna (Clemens and Wilby 1961; Hart 1973) only listed a northern record far to the west of Canadian territorial fishing

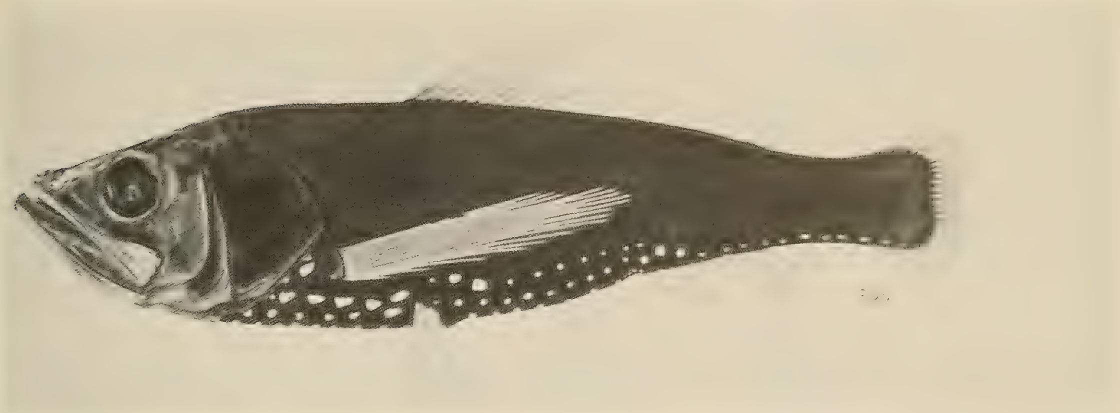

FIGURE 1. *Neoscopelus macrolepidotus* (BCPM 979–11145). Drawn by P. Drukker-Brammall.

waters (48°58′N, 144°21′W). Since then we have found two specimens taken by the "Brown Bear" in Canadian waters (Aron, 1960): one is from cruise 199, haul 317, 48°23′N, 131°41′W, ≦ 60 m, and 67 mm S.L. (= 76 mm F.L.); the other from cruise 199, haul 319, 48°23′N, 131°27′W, ≦ 40 m, 73 mm F.L. (= 65 mm S.L.). Aron (1960) also records a 22 mm T.L. specimen from cruise 202, haul 57, 47°58′N, 131°55′W, ≦ 60 m but we have not located that specimen.

Counts of our two Canadian specimens are: dorsal rays 13, anal rays 13-15, pectoral rays 14, vertebrae 16 + 20 - 21 = 36–37, lateral line scales 36–39, gill rakers 6–7 + 1 + 15, AO_a photophores 5–7, AO_p photophores 6, total AO photophores 11–13.

***Lampadena urophaos urophaos* Paxton Brightlight Lanternfish**

We have a specimen of *Lampadena urophaos* 107 mm S.L. (= 114.5 mm F.L. approx.) which is apparently the same specimen as *Lampadena* sp., 117 mm T.L. listed by Aron (1960) cruise 199, haul 321, 48°23′N, 131°13′W, ≦ 60 m depths, 18 August 1958. Clemens and Wilby (1961) and Hart (1973) did not include this species in their lists of western Canadian marine fishes. Although this record was quite verifiable at the time of their publications, the species was not described until later by Paxton (1963) who obviously had not seen our Canadian specimen. The species was previously known between 25° and 42°N to about 160°W (Nafpaktitis et al. 1977; Wisner 1974) and therefore our specimen at 48°N represents a 203 nautical mile northward extension of its known range and the first documented record off Canada. The remarkably enlarged infra- and supracaudal glands readily distinguishes this species from other lantern fishes in our region.

Counts are: dorsal rays 15, anal rays 14, pectoral rays 17, AO photophores 5 + 2 = 7, gill rakers 5 + 1 + 12 = 18, vertebrae 17 + 21 = 38, lateral line scales 38.

***Notoscopelus japonicus* Tanaka Spiny Lanternfish**

Peden et al. (*in press*) recounted the confused nomenclature of *Notoscopelus* in waters off British Columbia and the fact that none of the previously recognized records are from within the province's territorial fishing waters. Furthermore, the original records of Aron (1960) and Clemens and Wilby (1961) concerning *Notoscopelus* (Table 1) at the latitudes of British Columbia should be referred to as *N. japonicus* whereas Hart's (1973) record and illustration from Canadian waters may be a misidentified *Lampanyctus*. Pacific records of *N. resplendens* (Wisner 1974) suggest this congener resides well south of British Columbia.

We have found a specimen 127 mm S.L. (= 140 mm fork length (F.L.)) in Aron's collections (cruise 199, haul 317, 48°23′N, 131°41′W, ≦ 60 m). However, he does not list the specimen in his 1960 publication. Thus, the validity of the record must be questioned or it could have been switched for example with haul 90 where a 140 mm specimen is noted (see Table 1). Counts for the specimen are: dorsal rays 21, anal rays 18, pectoral rays 11, lateral line scales 42 + 3, gill rakers 7 + 1 + 16 = 24, Prc photophores 2 + 2, AO_a7, AO_p7.

***Protomyctophum crockeri* (Bolin) Penlight Fish**

Aron (1960) recorded a few specimens of *Protomyctophum crockeri* within the Canadian fishery zone off British Columbia and such a record is indicated on Wisner's (1974) distribution map even though the records were overlooked by Clemens and

TABLE 1. Specimens of probable *N. japonicus* from Brown Bear cruise 199 listed as *N. elongatus* by Aron (1960)

Haul Number	Latitude	Longitude	Depth in meters	Number of specimens	Total length in mm
57	49°24′N	140°38′W	30	2	135
90	47°28′N	146°24′W	60	1	140
230 (?I.D.)	33°46′N	125°12′W	180	1	68
236	33°31′N	126°40′W	120	1	25
243	32°10′N	128°43′W	60	7	32–40
248	33°06′N	129°24′W	30	6	30–38
252	35°10′N	130°12′W	30	2	56–58
253	35°13′N	130°13′W			75
113*	42°53′N	145°30′W	225		
146**	38°50′N	137°66′W	30	1	62
243**	38°50′N	137°66′W	30	1	53

*Not on species list.
**Previously identified by Aron as *Notoscopelus* sp.

Wilby (1960) and Hart (1973). We were unable to find any of Aron's specimens of this species.

In November 1983, we obtained four specimens of *P. crockeri* amongst hundreds of *P. thompsoni* at three localities: BCPM 983-1660, 48°47′N, 126°41.1′W; BCPM 983-1651, 50°9.23′N, 128°19′W; and BCPM 983-1630, 50°24.0′N, 128°34.5′W.

The species possesses 3 evenly spaced SAO photophores oriented in a straight line with the 1st SAO photophore usually above the last or fourth VO photophore. In contrast *P. thompsoni* usually has the SAO photophores unevenly spaced and not oriented in a straight line, and most important, the first SAO photophore lies above or in front of the third rather than the fourth VO photophore. Identification is further confirmed by the presence of 13 or 14 AO photophores rather than 16 (sometimes 15 or 17) found in *P. thompsoni*. Accordingly, we treat these specimens of 15, 16, 26 and 35 mm S.L. as the first verifiable records of *P. crockeri* in Canadian waters.

SERRIVOMERIDAE

***Serrivomer jesperseni* Bauchot-Boutin Crossthroat Sawpalate**

A single specimen of *Serrivomer jesperseni* (BCPM 980-299), 640 mm S.L. was donated to us through Dick Nagtegaal of the Nanaimo Biological Station. It was taken at 49°55′N, 126°35′W, 366-512 m, April 1980 by M/V Arctic Harvester. The arrangement of branchiostegal rays fits the pattern illustrated by Bauchot-Boutin (1953, 1954) and other features similar to those noted by Taylor (1967). Our specimen is much longer than the 406 mm size noted by Hart (1973) although Fitch and Lavenberg (1968), report 762 mm lengths for the congener, *S. sector*. Our specimen is the second published record off British Columbia. Counts are: dorsal rays 148, anal rays 142, total vertebrae 148.

TRICHIURIDAE

***Benthodesmus tenuis* (Gunther) Javelinfish**

We received a 625 mm S.L. specimen of *Benthodesmus tenuis* (BCPM 982-61), Figure 2, angled by a sport fisherman, Mr. Benny Smith, at about 20 ft. (6 m), off Pedder Bay on 26 April 1982. Other oceanic fish species have also been swept into this area near Race Rocks west of Victoria (Peden 1980: 179) and the occurrence of this specimen is therefore not unexpected. We also located a second specimen (UW 10102), 513 mm S.L., from Skunk Bay near Point No Point, Puget Sound, Washington, 24 March 1949. It was found alive at the surface and supports Tucker's (1953) assertion that species of *Benthodesmus* being weak swimmers are often found after they have been drawn up from deep water by tides and currents to become enfeebled by warmer surface waters.

Benthodesmus tenuis is easily separated from other species of *Benthodesmus* and especially *B. elongatus* which has been caught in the same general area (Peden 1980) on the basis of meristics alone, although eye size is also proportionally much smaller and useful for identification (see Table 2). The species was previously known from distant waters such as off Japan, the Philippines, Gulf of Mexico, southern Atlantic and mid-Pacific waters (Tucker 1955; Parin and Becker 1970) and therefore our specimen represents a major extension of its known geographic range.

***Aphanopus carbo* Low Black Scabbardfish**

Aphanopus carbo (Figure 3) was first reported from British Columbia by Peden (1975), but we now have a second specimen (BCPM 981-35), about 770 mm S.L., donated by the Nanaimo Biological Station. It was taken near an "area known as Clayoquot Canyon", 28 miles west of Sydney Inlet, Vancouver Island, by the M/V "Gail Bernice",

FIGURE 2. *Benthodesmus tenuis* (BCPM 982–61). Drawn by Norman Eyolfson.

TABLE 2. Counts and Measurements of *Benthodesmus*

	Bethodesmus tenuis			*Benthodesmus elongatus*		
	BCPM 982–61	UW 10102	Parin and Becker (1970)	BCPM 977–133	NMC 76–0444	Parin and Becker (1970)
Spinous dorsal rays	41	39	39–42	—	—	44–45
Soft dorsal rays	81	81	79–88	—	—	98–102
Total dorsal rays	122	120	119–129	146	142*	143–147
Anal rays	II, 74	II, 71	II, 69–75	II, 92	—	II, 90–92
Vertebrae	129	124	121–131	153	151	—
Standard length	581 mm	509 mm	—	895 mm	1054 mm* (approx.)	—
Head length/Standard Length	0.131	0.130	—	0.127	—	—
Orbit Length/Head Length	0.112	0.120	—	0.180	0.188*	—

*Gilbert 1917

13–19 March 1981, in 155–264 fm (292–500 m) depths. Counts (487 mm specimen first) are: dorsal rays XXXVIII-XV + 56 = 96–94, anal rays 49–46, vertebrae 44 - 46 + 59 - 57 = 103.

SCIAENIDAE

***Genyonemus lineatus* (Ayres)** **White Croaker**

We received a specimen of *Genyonemus lineatus* (BCPM 983-1412) trawled by a local fisherman, Mr. W. Egeland, in Swanson Channel, British Columbia (48°45′N, 123°20′W) at 55 m, March 1983. Although known from Baja California to Vancouver Island (Miller and Lea 1972; Hart 1973) the species is reported to be rare north of California (Eschmeyer et al. 1983; Rodel 1953) with the northernmost and previously only Canadian record based on one specimen captured from Barkley Sound (Hart 1973; Clemens and Wilby 1961) in 1945 (BCPM 945-7). Therefore the new specimen, 250 mm S.L., represents the second known occurrence in Canadian waters. Diagnostic characters are: tip of lower jaw included under snout, chin with minute barbels, a conspicuous black spot at the inside of each pectoral fin at upper corner of base, dorsal rays XII + I + 21, anal rays II, 11.

***Seriphus politus* Ayres** **Queenfish**

We have a specimen of *Seriphus politus* (BCPM 981-80) 63 mm S.L., captured near the mouth of Burrard Inlet off Vancouver, British Columbia, on 23 July 1981, through the courtesy of the Nanaimo Biological Station. The species is readily distinguished from other fishes of the region by its general body shape (Figure 4), non-projecting snout, space between dorsal fins greater than eye diameter, and anal soft rays 21–23 (Miller and Lea 1972).

The species was previously known between Baja California and Yaquina Bay, Oregon (Miller and Lea 1972) and therefore the Canadian record represents a 500 km northward extension of known occurrence. Counts are: dorsal rays VII + I (II?) + 19; anal rays

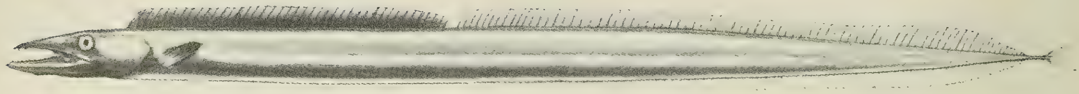

FIGURE 3. *Aphanopus carbo* (OSU 549, off Oregon). Drawn by Norman Eyolfson. Tail reconstructed from Eschmeyer et al. (1983).

II + 21; pectoral rays 18; lateral line scales 60; gill rakers 9 + 18.

EMBIOTOCIDAE

***Amphistichus rhodoterus* (Agassiz)**

Redtail Surfperch

Hart (1973) records *Amphistichus rhodoterus* from California to Hesquiat Harbour on the west coast of Vancouver Island. We have numerous specimens from outside Kyuquot Channel (BCPM 980-393), outside Cook's Lagoon on the Brooks Peninsula (BCPM 981-70), and Roller Bay, Hope Island (BCPM 980-370) which constitute more northerly records and suggest the species occurs along most exposed surf-swept beaches throughout the length of Vancouver Island.

***Hyperprosopon ellipticum* (Gibbons)**

Silver Surfperch

Collection of several specimens from the Brooks Peninsula (BCPM 981-70) extends the known range nearly 150 miles northwestward from Peden's (1966) record at Schooner Cove. This is another species that might be expected on most exposed sandy beaches along the length of Vancouver Island.

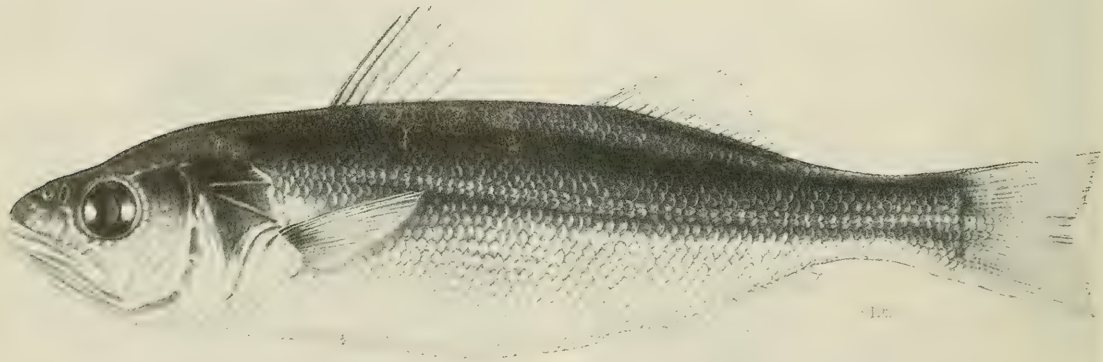

FIGURE 4. *Seriphus politus* (BCPM 981-80). Drawn by P. Drukker-Brammall.

COTTIDAE

***Icelus spiniger* Gilbert** **Thorny Sculpin**

Hart (1973) refers to a specimen (NMC 65–330) captured at 54°37′N, 133°55′W (Barraclough 1971) as the only record of *Icelus spiniger* from British Columbia. This locality would have been "Canadian" if the international boundary off Cape Muzon and claimed by Canada extended westward. However, recent charts (Canadian Hydrographic Service 1982) exclude the location from territorial fishing waters.

A second specimen was listed by Barraclough (1971) off Alice Arm, Vancouver Island at 50°28′N, 127°29′20″W (UBC 65–133), however our pilot books (Chivas 1974; Jones 1974) and gazetteer (Canadian Permanent Committee on Geographic Names 1966) list Alice Arm much further north at approximately 55°N and 129°W. Although Barraclough may have meant "Port Alice", British Columbia, we follow Hart (1973) and reject that Vancouver Island record.

Coincidentally, we obtained another specimen (NMC 81–117) from Alice Arm as our first verifiable record for the Province. This specimen, 81 mm S.L., was taken on "side of the inlet near head of deep trough . . . about 4 km S.W. of Alice Arm Post Office", 7 September 1980, by Dobrocky Seatech Ltd. Since that time we have also received five more specimens (BCPM 982-333, BCPM 982-334) taken in Alice Arm by Randy Kashino of Dobrocky Seatech Ltd.

Recently we received our most southerly record for the species through the courtesy of Dobrocky Seatech Ltd. and the Institute of Ocean Sciences, Sidney, British Columbia. This 81 mm S.L. specimen (BCPM 984-145) was taken in the La Perouse Bank area, 48°35.8′N, 125°24.4′W, in 133 m, with a bottom sled, May 1981. *Icelus spiniger* is readily separated from other sculpins of the Province because of the conspicuous postorbital and occipital spines, the row of scales below the dorsal fin with a very large conspicuous spine on each scale, and the 3 soft pelvic fin rays.

BYTHITIDAE

***Spectrunculus grandis* (Gunther)** **Giant Cuskeel**

Spectrunculus grandis was previously recorded under the name of *Parabassogigas grandis* from seven localities off Oregon (Eagle 1969) and Jean et al. (1982) briefly refer to two specimens received from the Nanaimo Biological Station, but apparently confused the locality data of another specimen from 48°18.6′N, 127°00.9′W (BCPM 976–1087). Here we confirm the records of six specimens from British Columbia fishing waters. Collection BCPM 976-1087 possesses one specimen, 363 mm S.L., from 48°16′36″N, 127°00′54″W, 2520 m, 2 September 1971, and donated to BCPM through exchange with California Academy of Sciences; BCPM 979–11365, two specimens, 811–1050 mm S.L., off Tasu Sound, Queen Charlotte Islands, 2835 m, 16 August 1979; BCPM 980–121, three specimens, 52°38′N, 132°05′48″N, 2835 m, 4 February 1980. The latter two collections represent gifts from the Nanaimo Biological Station. The genus can be distinguished from other fishes in the region by its general body shape (Figure 5). Cohen and Nielsen (1978) characterize both *Parabassogigas* Nybelin and *Spectrunculus* Jordan and Thompson and diagnose the former with "Head more than 2 times in preanal length in adults, less in juveniles. Snout longer than eye. Opercular spine strong. Median basibranchial tooth patches 2. Vomer with a diamond-shaped tooth patch. Developed rakers on first arch, 7 or 8. Pectoral rays 21 to 27; fin short, not reaching vent. Ventral fins with 2

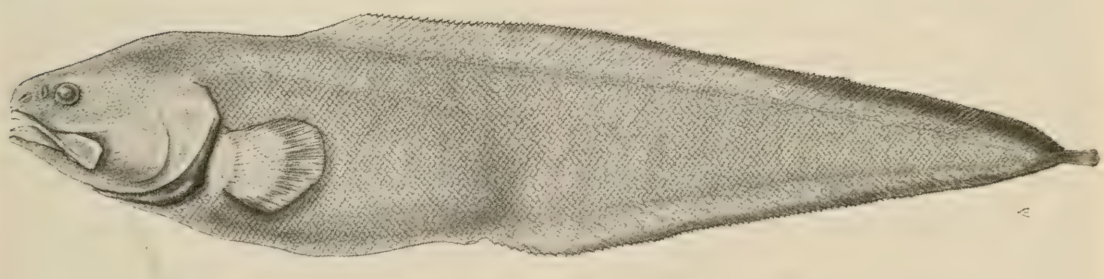

FIGURE 5. *Spectrunculus grandis* (BCPM 980–121). Drawn by Karen Uldall-Ekman. Some detail taken from right side of head.

rays in each. Branchiostegal rays 8. Precaudal vertebrae 19 to 24. Lateral line short." They further suggest *Spectrunculus* may represent juvenile *Parabassogigas* and we adopt the generic name with precedence pending studies by Nielsen (see Jean et al. 1982).

Counts for three of our specimens are: dorsal rays 129–135, anal rays 102–104, pectoral 27–29, vertebrae 23 + 56 - 58 = 79–81, heads 0.351–0.378 of preanal length, eye diameter 0.364–0.514 of snout length.

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Effects of Shrub Coverages on Birds of North Dakota Mixed-grass Prairies

TODD W. ARNOLD[1] and KENNETH F. HIGGINS[2]

U.S. Fish and Wildlife Service, Northern Prairie Wildlife Research Center, Jamestown, North Dakota 58401
[1]Present address: School of Forestry, Fisheries, and Wildlife, 112 Stephens Hall, University of Missouri, Columbia, Missouri 65211
[2]Please direct requests to K. F. Higgins.

Arnold, Todd W., and Kenneth F. Higgins. 1986. Effects of shrub coverages on birds of North Dakota mixed-grass prairies. Canadian Field-Naturalist 100(1): 10–14.

We studied the distribution and density of passerine birds in relation to Wolfberry (*Symphoricarpos occidentalis*) and Silverberry (*Elaeagnus commutata*) shrub coverages on mixed-grass prairies of central North Dakota. Birds were counted along shrubby and shrubless transects during the 1982 breeding season. Species richness and total density of birds were greater on shrubby transects. Five species were more abundant on shrubby transects. Availability of woody nesting substrates best explained differences in bird species abundances. Differences in shrub coverages between transects were probably the result of different land-use practices. Land management practices which modify shrub coverages can alter the composition of passerine bird communities.

Key Words: Bird communities, mixed-grass prairies, North Dakota, range management, *Symphori carpos occidentalis*, Wolfberry, *Elaeagnus commutata*, Silverberry.

Bird species diversity is positively correlated with foliage height diversity (MacArthur and MacArthur 1961; Willson 1974). In central North Dakota, vertically structured shelterbelts and prairie thickets have more species, higher densities, and higher diversities of birds than nearby upland native prairies (Faanes 1982). In western shrubsteppe environments, bird species abundances are highly correlated with shrub species coverages and factors of shrub physiognomy (Rotenberry and Wiens 1980; Wiens and Rotenberry 1981). The effects of shrub removal on bird communities have been studied for some western sagebrush habitats (Best 1972; Braun et al. 1976; Castrale 1982), but little is known about bird species responses to shrub removal in other habitat types.

Wolfberry (*Symphoricarpos occidentalis*) and Silverberry (*Elaeagnus commutata*) are common shrub species on mixed-grass prairies of the northern Great Plains (Coupland 1950; Bailey 1970; Stephens 1973). Both species increase in height and abundance on undisturbed areas and cattle pastures (Pelton 1953; Corns and Schraa 1965; Van Bruggen 1976). Frequent sheep grazing or mowing, however, reduce these shrubs (Corns and Schraa 1965; Johnson 1975). These two shrub species are often controlled with herbicides or fire (McCarty 1967; Anderson and Bailey 1979, 1980). In this study, we relate differences in passerine bird communities to the abundance or scarcity of Wolfberry and Silverberry shrubs.

Study Area and Methods

This study was conducted in the Missouri Coteau physiographic region of south-central North Dakota. Privately-owned quarter sections (64.5 ha) of native prairie pasture served as study plots. We purposely selected plots exhibiting the land-use history and vegetative structure we wished to study. Five cattle pastures where shrubs were predominant were selected as shrubby plots. Wolfberry and Silverberry were prominent over 30 to 80% of these areas. A few isolated thickets of Chokecherry (*Prunus virginiana*) and Hawthorn (*Crataegus* spp.) occurred on two of the shrubby plots. These thickets were taller (2-3 m) and less extensive (< 10 m diameter) than the low (usually < 1.5 m) and expansive (up to 1 ha) stands of Wolfberry and Silverberry. Five plots where shrubs were reduced in coverage to 10% or less of the census area were selected as shrubless plots. Three of these plots were sheep pastures, one was a prairie hayfield, and one was a cattle pasture that had been treated with herbicide in 1969. Shrubless plots were paired adjacent to shrubby plots, except for one instance when a pair of plots was separated by 0.8 km. No major differences existed in local topography or soils between pairs of plots. The differences in shrub coverage were assumed to be due primarily to land-use history. Grazing intensity ranged from light to heavy among both shrubby and shrubless plots.

Birds were censused using a single 400–m variable-strip transect in each study plot (Emlen 1977). Transects were centrally positioned in each study plot to avoid large wetlands and prairie thickets. Wetlands made up 1 to 11% of the transect areas but were deleted from total area before computing bird densi-

ties. Birds in wetlands were not censused. Counts were conducted from sunrise until 3 hours after sunrise on mornings with mild winds (< 20 km/h) and no precipitation (Mikol 1980). Transects were censused six times between 19 May and 29 June 1982. Norling (unpublished data) conducted additional censuses during a 1981 pilot study.

We recorded species, sex (if determinable), distance from transect (to nearest 5 m), and behavioral/detectional cues (e.g. song, call note, visual on perch, visual in flight) for all passerines detected during the counts. Density estimates were computed using Emlen's (1977) methods with modifications suggested by Franzreb (1981). Species-specific strip widths were determined by visually estimating the inflection points on histograms of lateral detection distances. Density estimates of breeding pairs were determined for most species using detections of singing males and paired birds. For Brown-headed Cowbirds (see Table 2 for scientific names of birds), density estimates were computed using a total count of individuals of both sexes.

We collected data on the composition and structure of the vegetation for each study plot on 20 and 21 July 1982. Vegetative composition was quantified by visually estimating the percent areal coverage of each plant life form (e.g. grass, forb, shrub) within a 1.0×0.5-m quadrat frame. Vegetation was sampled at 50 points, approximately 16 m apart along transects parallel and approximately 30 m to either side of the bird-censusing transects. The heights of Wolfberry, Silverberry, and Rose (*Rosa* spp.) shrubs present within quadrat frames were measured. A modified version of the visual-obstruction pole (Robel et al. 1970; Higgins and Barker 1982) was used to quantify vertical vegetation structure at 25 sample points located randomly within 50 m of each bird-censusing transect. Because we could neither demonstrate or assume normal data distributions, we used Mann-Whitney U tests for comparisons of all bird and vegetation data.

Results

Vegetation

Mean areal coverage of shrubs was greater on shrubby transects (Table 1). Wolfberry and Silverberry were more abundant and taller on shrubby transects. Prairie Wild Rose (*Rosa arkansana*) and Wood's Rose (*R. woodsii*) were of similar height and abundance on shrubby and shrubless transects. Mean areal coverage of grasses and forbs and mean visual obstruction (height-density) of vegetation did not differ significantly between shrubby and shrubless transects.

TABLE 1. Vegetative characteristics of shrubby and shrubless transects.

Vegetative Characteristics	Shrubby Transects	Shrubless Transects	P
Mean Areal Coverage (%)			
Grasses	72.1	65.8	0.21
Forbs	20.5	27.8	0.53
Shrubs	35.0	3.7	0.01
Mean Visual Obstruction (dm)			
Height-density	1.74	1.06	0.21
Frequency of Occurrence (%)			
Wolfberry	92	39	0.01
Silverberry	26	1	0.01
Rosa spp.	5	15	0.53
Mean Shrub Height (cm)			
Wolfberry	44.7	23.9	0.01
Silverberry	74.8	23.0	0.01
Rosa spp.	18.5	13.4	0.72

Birds

We recorded 21 species of passerines during this study, 19 on shrubby transects and 10 on shrubless transects. Species richness and total passerine density were higher on shrubby transects, although these differences were not quite significant (Table 2). Eleven species were recorded only on shrubby transects, whereas two species were recorded only on shrubless transects. Eastern Kingbirds, Common Yellowthroats, Clay-colored Sparrows, Red-winged Blackbirds, and Brown-headed Cowbirds were all more abundant on shrubby transects (Table 2). Results from 1981 (Norling, unpublished) are not directly comparable with our data, but estimates of species richness, total density, and densities of these five species were higher on shrubby transects in 1981, lending support to our conclusions.

Clay-colored Sparrows and Brown-headed Cowbirds were the two most abundant species on shrubby transects; together they composed 57% of the total passerine density on shrubby transects. Chestnut-collared Longspurs and Grasshopper Sparrows composed 49% of the total passerine density on shrubless transects. Grasshopper Sparrows, Western Meadowlarks, Red-winged Blackbirds, and Brown-headed Cowbirds were dominant members of both shrubby and shrubless bird communities.

Discussion

Shrubby and shrubless transects did not differ in any of the vegetation characteristics we examined except Wolfberry/Silverberry coverage and height. Thus, it is reasonable to assume that many of the differences we observed in bird species abundances were related to shrub characteristics.

TABLE 2. Density estimates (birds/km²) of breeding passerines on shrubby and shrubless transects.

Species	Shrubby Transects		Shrubless Transects		P
Willow Flycatcher, *Empidonax traillii*	8.4[a]	0–30.0[b]	0	0–0	0.21
Western Kingbird, *Tyrannus verticalis*	5.3	0–26.3	0	0–0	0.21
Eastern Kingbird, *T. tyrannus*	35.8	10.5–56.5	2.6	0–13.0	0.02
Horned Lark, *Eremophila alpestris*	11.5	0–29.9	19.6	0–67.0	0.92
Gray Catbird, *Dumetella carolinensis*	1.2	0–6.0	0	0–0	0.39
Brown Thrasher, *Toxostoma rufum*	3.4	0–14.2	0	0–0	0.39
Yellow Warbler, *Dendroica petechia*	6.8	0–28.5	0	0–0	0.21
Common Yellowthroat, *Geothlypis trichas*	8.4	0–14.5	0	0–0	0.04
Clay-colored Sparrow, *Spizella pallida*	163.0	75.9–253.0	0	0–0	0.01
Vesper Sparrow, *Pooecetes gramineus*	3.5	0–17.5	0	0–0	0.39
Savannah Sparrow, *Passerculus sandwichensis*	0	0–0	7.0	0–25.2	0.09
Baird's Sparrow, *Ammodramus bairdii*	0	0–0	5.4	0–20.6	0.21
Grasshopper Sparrow, *A. savannarum*	17.8	0–70.0	57.6	0–164.9	0.25
Song Sparrow, *Melospiza melodia*	1.1	0–5.5	0	0–0	0.39
Chestnut-collared Longspur, *Calcarius ornatus*	1.1	0–5.7	63.9	0–228.7	0.21
Bobolink, *Dolichonyx oryzivorous*	2.5	0–7.0	12.5	0–23.7	0.30
Red-winged Blackbird, *Agelaius phoeniceus*	62.6	59.2–65.0	23.3	6.0–49.7	0.01
Western Meadowlark, *Sturnella neglecta*	23.3	7.8–25.0	27.1	9.8–34.5	0.92
Yellow-headed Blackbird, *X. xanthocephalus*	3.4	0–17.0	0	0–0	0.39
Brown-headed Cowbird, *Molothrus ater*	102.4	89.7–122.4	31.5	14.9–55.4	0.01
American Goldfinch, *Carduelis tristis*	5.2	0–14.1	0	0–0	0.21
Total Passerines	466.9	363–611	250.4	83–393	0.06
Species Richness	10.0	8–16	6.6	4–9	0.06

[a]Mean density [b]Range

The availability of woody nesting substrates was probably the most important factor promoting greater species richness and densities on shrubby transects (see Tomoff 1974). Of the five species that were significantly more abundant on shrubby transects, Eastern Kingbirds and Clay-colored Sparrows nest almost exclusively in shrubs, Common Yellowthroats nest in elevated vegetation (including shrubs), and Brown-headed Cowbirds are obligate nest parasites (Johnsgard 1979). Of the 11 species detected only on shrubby transects, 9 were shrub nesters, including Willow Flycatchers, Gray Catbirds, Brown Thrashers, Yellow Warblers, Song Sparrows, and American Goldfinches (Johnsgard 1979).

Shrubless transects provided grass and forb nesting substrates similar to those found on shrubby transects; thus, most ground-nesting species occurred on both shrubless and shrubby transects. Savannah and Baird's Sparrows, however, occurred only on shrubless transects.

Grazing intensity was apparently more important than shrub coverage in determining densities of some ground-nesting birds (see Owens and Myres 1973; Kantrud 1981; Kantrud and Kologiski 1982). Our highest densities of Horned Larks occurred on transects with the lowest height-densities of vegetation (heavily grazed), regardless of the presence or absence of shrubs. Grasshopper Sparrows and Bobolinks occurred in highest densities on transects with the highest vegetation height-densities (lightly grazed), including both shrubby and shrubless transects. Because grazing intensity varied from light to heavy within both shrubby and shrubless study plots, differences in bird densities related to grazing should be obscured in our comparisons.

In other grassland and shrubsteppe bird studies, the distribution of shrubs affected certain bird species abundances. In southwest Manitoba, Clay-colored Sparrows nested almost exclusively in Wolfberry and Silverberry shrubs (Knapton 1978). In North Dakota, Kantrud (1981) observed high densities of Common Yellowthroats, Clay-colored Sparrows, and Vesper Sparrows in conjunction with terminal moraines, which have an abundance of shrubs. Wiens and Rotenberry (1981) observed that densities of several passerine species correlated with various aspects of shrub physiognomy, shrub species diversity, and shrub species coverages. In central North Dakota, Faanes (1982) observed that Willow Flycatchers, Eastern Kingbirds, Gray Catbirds, Brown Thrashers, Yellow Warblers, Common Yellowthroats, Song Sparrows, Red-winged Blackbirds, and American Goldfinches reached their maximum breeding densities in prairie thickets, whereas Clay-colored Sparrows reached their maximum in Wolfberry patches on upland prairies.

The occurrence of prairie thickets (Chokecherry and Hawthorn shrubs) on two of our shrubby transects appeared to be responsible for the presence of most Willow Flycatchers, Gray Catbirds, Brown Thrashers, and Song Sparrows. Many other bird species were frequently detected in prairie thickets. Chokecherry and Hawthorn increase in abundance under the same conditions that favor Wolfberry and Silverberry (personal observations). Although we did not include prairie thickets in our study design, we suspect that land-use practices which modify Wolfberry and Silverberry coverages may also modify prairie thicket coverages, thereby altering the composition of passerine bird communities.

Our results indicate that many species of passerine birds are not attracted to mixed-grass prairies with reduced coverages of Wolfberry and Silverberry. Only a few bird species may benefit from shrub reduction. Land management practices that promote or maintain sizeable tracts of shrubs will favor higher densities and species richness of passerine birds; however, some of this increase may be due to invasion by non-prairie species (e.g. Willow Flycatcher, Gray Catbird, Brown Thrasher).

Many areas of prairie that are left idle or are lightly to moderately grazed by cattle eventually become overgrown with shrubs, which is attractive to many species of passerine birds. Prairie management that involves repeated prescribed burning reduces Wolfberry and Silverberry coverages (Bailey and Anderson 1978; Anderson and Bailey 1979), but patches of shrubs can be maintained by employing partial burns (Kruse et al. 1983). If herbicides are used to control shrubs, patches or strips of shrubs can be skipped over during application procedures (Castrale 1982).

Where reduction or elimination of shrubs is desired, species richness and density of passerine birds can be expected to decline; however, a few species are likely to benefit. In particular, sheep grazing seems to favor Horned Larks and Chestnut-collared Longspurs (Owens and Myres 1973) and haying seems to favor Common Yellowthroats, Savannah Sparrows, and Bobolinks (Kantrud 1981).

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Aquatic Vascular Plants in Sibley Provincial Park in Relation to Water Chemistry and Other Factors*

D. FRASER,[1,2] J. K. MORTON,[3] and P. Y. JUI[4]

[1]Ontario Ministry of Natural Resources, Wildlife Research Section, Box 50, Maple, Ontario L0J 1E0
[2]Present address: Animal Research Centre, Agriculture Canada, Ottawa, Ontario K1A 0C6
[3]Department of Biology, University of Waterloo, Waterloo, Ontario N2L 3G1
[4]Engineering and Statistical Research Institute, Agriculture Canada, Ottawa, Ontario K1A 0C6
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Thirty-seven species of submersed and floating-leafed vascular plants were found in 24 lakes in Sibley Provincial Park, Ontario. Plant distributions were studied in relation to the physical and chemical characteristics of the lakes. Unlike lakes in typical granitic areas of the Canadian Shield, most of the Sibley lakes were in areas of sedimentary bedrock which imparted a relatively high total alkalinity (30–139 ppm $CaCO_3$) to the water. The lakes were dominated by typical hardwater plants such as *Potamogeton filiformis, P. foliosus, P. praelongus, P. strictifolius, P. zósteriformis*, and *Myriophyllum exalbescens*, and by species that tolerate a wide range of alkalinities (e.g. *Potamogeton berchtoldii, Nuphar variegatum,* and *Sparganium angustifolium*). Several lakes in the park occurred on a different type of bedrock. These had lower alkalinities (14–33 ppm) and contained a number of softwater plant species such as *Potamogeton spirillus, P. epihydrus*, and *Sparganium fluctuans*. However, several softwater species which are common on the Canadian Shield were not found in the park. Distribution of most species was not closely related to type of shoreline or to levels of major plant nutrients (nitrogen, phosphorus, potassium and sodium) in the water. Typical sediment types and depths were noted for several species.

Key Words: Aquatic plants, Canadian Shield, water chemistry, lake sediment, alkalinity, Ontario.

Many of the lakes on the Canadian Shield occur in areas of slow-weathering granitic bedrock, and consequently have low levels of dissolved minerals in the water. Since dissolved minerals exert a major influence on aquatic vegetation, the floras of many Shield lakes are dominated by certain characteristic softwater species. Such floras have been described in northern Minnesota (Moyle 1945), Muskoka (Miller and Dale 1979), southeastern Ontario (Crowder et al. 1977), Gatineau Park (Aiken and Gillett 1974), and Lake Superior Provincial Park (Fraser and Morton 1983).

However, the Shield also includes some areas of sedimentary bedrock that tend to impart a higher mineral content to surface waters. The Sibley Group, named because it dominates the Sibley Peninsula, is an important sedimentary series occurring at various locations near the north shore of Lake Superior. Compared to granitic Shield rocks, the Sibley sediments give rise to much higher levels of bicarbonate in lake water, and even support a few mineral-rich springs (Tanton 1931).

In this study, our objective was to document the species of aquatic vascular plants in the Sibley Peninsula and their occurrence in relation to water chemistry and other factors. Most of the lakes are located in areas of Sibley Group bedrock, but by including several lakes on other geological formations in the peninsula, we were able to compare the floras of mineral-rich and mineral-poor water in the same local area.

Study Area

The study was carried out in Sibley Provincial Park, Ontario, a 243 km^2 area on the Sibley Peninsula on the north shore of Lake Superior. The Park is dominated by boreal forest, and includes numerous small, shallow lakes.

Rock outcropping in the peninsula consists of three units, all of Precambrian age: (1) the Rove formation of deep water carbonaceous argillite, greywacke and limestone, (2) the Sibley formation of red beds and shallow marine deposits unconformably overlying the Rove formation, and (3) numerous Keweenawan diabase dykes and sills intruding into the sedimentary strata along an extensive fracture system (Tanton 1931; Ontario Division of Mines 1973). Soils consist of silty to sandy till mainly on the west side of the peninsula, and a mixture of till and lacustrine sand mainly on the east (Ontario Department of Lands and Forests 1965).

Twenty-four lakes were chosen for the study to give a variety of surface areas, depths, types of shorelines, and types of bedrock. When possible, lakes with easy ground access were chosen. All lakes reported to attract numerous Moose (*Alces alces*) were included because the work was related to a study of aquatic

habitats used by Moose. The study lakes range from 0.2 to 66.1 ha surface area, with mean depths of 0.3 to 4.6 m. Nineteen are located in areas where outcropping rock is of the Sibley Group. The other five are in areas dominated by the Rove formation, diabase, or a combination of the two. Lake names follow Canada Department of Energy, Mines and Resources (1975). Locations of unnamed lakes used in the study are as follows: Lake 1A (48°28.4′N, 88°49.1′W), Lake 1B (48°28.5′N, 88°48.8′W), Lake 7A (48°27.6′N, 88°45.0′W), Lake 7B (48°27.5′N, 88°45.3′W), Lake 13A (48°24.8′N, 88°49.5′W), Lake 15A (48°25.1′N, 88°45.3′W), Lake 15D (48°24.8′N, 88°45.8′W), and Lake 24A (48°21.6′N, 88°45.8′W).

Methods

Information was gathered during several visits to each lake between May 1976 and July 1980. Aerial photographs and ground checks were used to assign percentages of shoreline types around each lake, the types being (1) bare bedrock and talus, (2) peat bog, mainly dominated by *Sphagnum*, and (3) soil or stone and soil, mainly dominated by forest but with marshy edges in places.

In each lake, scoops of sediment were examined from a canoe at numerous locations where water depth was < 2 m, the zone in which virtually all aquatic vegetation was observed to grow. The lake was then divided into two to six sediment zones with a new zone beginning where the nature of the sediment changed noticeably. The zones were marked on a map of the lake, and a composite sample of sediment from each zone was collected and air-dried. These were later tested for organic content by loss on ignition, and the results were averaged, with weighting based on the relative areas of the different zones.

One mid-lake surface water sample was collected from each lake in May-June 1976 and another in July 1977. These were analyzed to give information on standard limnological measures (specific conductance, total alkalinity, pH, and color), on major plant nutrients (total Kjeldahl nitrogen, total phosphorus, and potassium), and on sulphate because of its apparent influence on aquatic vegetation (Moyle 1945). Sodium levels were also determined, originally because of their possible relevance to aquatic feeding by Moose. Recently, Faaborg (1981) has shown that sodium is a significant nutrient for some aquatic vegetation. The analytic techniques are described in Ontario Ministry of the Environment (1975). Specific conductance, total alkalinity, pH, color, and sulphate showed close agreement between the two years, with little seasonal variation as shown by a series of supplementary samples. Therefore, the mean of the 1976 and 1977 values was used for these variables. Nitrogen, phosphorus, potassium, and sodium varied considerably over the season, presumably because of plant metabolism. Therefore, additional samples were collected in May of 1978 and 1979, soon after ice disappeared from the lakes and before significant plant growth became apparent. The mean of these two values was used in the analysis, as this was considered a better estimate of the quantity of these nutrients typically available in the lakes at the beginning of the growing season.

Aquatic vegetation was examined initially in 1976. Submersed and floating-leafed macrophytes were collected and identified in all lakes, and voucher specimens were deposited in the herbarium of the University of Waterloo, Waterloo, Ontario. Abundance of each species was estimated in August and early September 1977 for all lakes. A canoe or boat was paddled near the shoreline and in several lines criss-crossing the lake. Areas less than 2 m in depth were divided into sections, with a new section beginning where the nature or abundance of vegetation changed substantially. Sections were marked on an outline map, and the abundance of each species was estimated as the approximate percentage of lake bottom covered by the plants as if seen from above. Estimates for sections were then combined for each lake. The extreme shallowness of Joeboy Lake allowed a more precise survey based on 349 plots along four transect lines as described by Fraser and Hristienko (1983).

In comparing chemical properties of the lakes, the Mann-Whitney U test and rank order correlations were used in order to avoid the assumption of equal variance. A grouping of the plant species was achieved by cluster analysis using an incremental sum of squares method (Anderberg 1973). Ten species were omitted from the cluster analysis because they occurred in fewer than four lakes. Each of the remaining species was noted simply as being present or absent in each lake. Jaccard matching coefficients were then calculated for pairs of species based on the proportion of lakes in which the species occurred together, but ignoring any lakes where both plants were absent.

Results

The 24 lakes showed a wide range of total alkalinity (equal to bicarbonate alkalinity in all cases) and specific conductance (Table 1). The 19 lakes on Sibley Group rock had much higher levels of total alkalinity than lakes on largely granitic areas of the Canadian Shield reported by Fraser and Morton (1983). The five lakes on the Rove formation or diabase had significantly lower levels of total alkalinity ($P < 0.05$), specific conductance ($P < 0.05$), and pH ($P < 0.10$), and slightly higher levels of sodium and potassium, com-

TABLE 1. Water chemistry of five lakes on bedrock of the Rove formation or diabase, compared with 19 lakes on Sibley Group bedrock.

Variable	Mean (range)		
	Rove and diabase	Sibley Group	P[1]
Specific conductance (μmhos)	58 (26-86)	144 (63-255)	< 0.05
Total alkalinity (ppm $CaCO_3$)	24 (14-33)	76 (30-139)	< 0.05
pH	6.9 (6.5-7.5)	8.0 (6.9-8.6)	< 0.10
Color (Hazen units)	39 (10-150)	36 (9-125)	n.s.
Total Kjeldahl nitrogen (ppm)	0.53 (0.27-1.24)	0.53 (0.25-0.85)	n.s.
Total phosphorus (ppb)	15.0 (7.5-26.5)	13.1 (6.5-23.5)	n.s.
Potassium (ppm)	0.83 (0.33-1.13)	0.65 (0.48-0.93)	n.s.
Sodium (ppm)	1.14 (0.60-1.80)	0.70 (0.45-1.20)	n.s.
Sulphate (ppm)	10.3 (8.0-14.0)	7.5 (2.0-12.5)	n.s.

[1]Statistical significance of the difference by the Mann-Whitney *U* test, 2-tailed.

pared to the lakes on Sibley Group rock (Table 1).

Levels of total alkalinity and specific conductance were highly correlated (Table 2), and both measures correlated with pH. Presumably this was due to the fact that all three variables were strongly influenced by the level of bicarbonate in the water. Levels of major plant nutrients (nitrogen, phosphorus, potassium, and sodium) tended to be correlated, and they showed no relationship to alkalinity, specific conductance, and pH. The amount of bog shoreline was related to the levels of nitrogen and color in the water ($r = 0.67$ and 0.68 respectively, $P < 0.01$), but other aspects of shoreline type, sediment, depth, and surface area were not significantly related to water chemistry.

Submersed and floating-leafed plants found in the 24 lakes are listed in Table 3. Typically emergent species were not recorded systematically. However, *Sparganium chlorocarpum* (Bur-reed), *S. eurycarpum* (Bur-reed), *Typha latifolia* (Common Cat-tail), *Equisetum fluviatile* (Horsetail), *Sagittaria latifolia* (Duck-potato), and emergent species of *Eleocharis* (Spike-Rush) were commonly observed. *Elodea canadensis* (Waterweed) and *Lemna minor* (Duckweed) were found in some lakes in the Sibley peninsula, but not in the 24 study lakes. In many cases, field identifications had to be based on immature specimens. Most of these were considered straightforward. However, specimens of *Sparganium* from lakes 15D, Lizard, Helen, and Norma were considered to be *S. angustifolium*, but some could have been floating-leafed *S. chlorocarpum*. (Recently, Packer (1983) concluded that these two plants are conspecific and combined them under the former name).

Using the cluster analysis as a starting point, the 37 species could be divided into several categories. The eight most abundant species (indicated by a letter A in front of the plant name in Table 3) occurred in 16 to 23 lakes each. Three of these species (*Sparganium angustifolium*, *Potamogeton berchtoldii*, and *Nuphar variegatum*) occurred throughout the range of total alkalinity, while the other five were absent from the four lakes with total alkalinity < 30.

Seventeen species (indicated by letter B in Table 3) were of intermediate abundance, occurring in 4 to 13 lakes each. Of these only *Hippuris vulgaris*, *Utricularia minor*, *Callitriche palustris* and *Utricularia intermedia* were found in water with total alkalinity < 30.

Two species (indicated by letter C in Table 3) were

TABLE 2. Rank order correlations among the water chemistry variables.

Variable	TA	pH	color	TKN	TP	K	Na	SO_4
Specific conductance (SC)	0.97**	0.60**	−0.03	−0.02	−0.13	−0.30	−0.38	−0.25
Total alkalinity (TA)	—	0.61**	−0.04	−0.07	−0.10	−0.27	−0.34	−0.31
pH		—	−0.16	0.03	0.03	−0.07	−0.08	−0.35
Color			—	0.61**	0.18	0.01	−0.05	0.29
Total Kjeldahl nitrogen (TKN)				—	0.45*	0.19	−0.18	−0.11
Total phosphorus (TP)					—	0.57**	0.11	−0.12
Potassium (K)						—	0.60**	0.21
Sodium (Na)							—	0.24
Sulphate (SO_4)								—

$*P < 0.05$, $**P < 0.01$, 2-tailed. $N = 24$ lakes.

TABLE 3. Submersed and floating-leafed aquatic plants in the 24 lakes, with lakes arranged in order of decreasing total alkalinity. Plants at the top of the list were found mainly in lakes of high alkalinity, those at the bottom mainly in lakes of low alkalinity.

		Holt	15 D	Grassy	7 A	Sawbill	Joeboy	Lizard	Gardner	7 B	1 B	1 A	24 A	Pickerel	Norwegian	13 A	Rita	Fern	15 A	Talus	Kay	Helen	Norma	Calcite	Legend
	Species	139**	133	105	100	93	90	83	79	70	70	66	64	63	60	58	58	51	40	33	30	27	25	22	14
	Potamogeton pectinatus Sago Pondweed	1					4																		
B*	*Potamogeton filiformis* Pondweed	1		3			1	3	2		1	3		1											
B	*Megalodonta beckii* Water-Marigold	3						3	1						2										
B	*Myriophyllum verticillatum* Water Milfoil				1		2	1				1	4												
B	*Myriophyllum exalbescens* Water Milfoil	3					4	3	3			4					2	2		2					
B	*Potamogeton zosteriformis* Flat-stem Pondweed	2	5		3		4	2	4				3		1	3									
B	*Polygonum amphibium* Water-smartweed	1	1			1			1				1	1	1	2					1				
B	*Utricularia vulgaris* Bladderwort	1		2	4		1	2	1		1	2		2	2	3	1				2				
B	*Potamogeton strictifolius* Pondweed			4	2		1		4					1	1										
	Potamogeton richardsonii Red-head Pondweed						1													2					
A	*Potamogeton foliosus* Pondweed		4	3	3	2	5	2	5	4	2	4	4	2	2	1	1	3	3						
A	*Potamogeton gramineus* Pondweed	3	3	3	2	2	3	2		1		3		2	2	2	2	3		4	2				
A	*Najas flexilis* Naiad	3		4	4	2	5	3	5		4	4	3	2	2	2	1	1	3	2	4				
A	*Potamogeton praelongus* White-stem Pondweed	2		4	4	1	4	4	4	2	3	3		3	1	4	4	4	4		4				
B	*Hippuris vulgaris* Mare's-tail	2	3		3		2		2				4												1
	Ranunculus longirostris White Water-Crowfoot						2								1										
	Ranunculus trichophyllus White Water-Crowfoot								3			2													
	Potamogeton robbinsii Pondweed								5																
B	*Callitriche palustris* Water-starwort		3					1		3			3							1		2	2		
B	*Potamogeton alpinus* Pondweed			3		1			2	1	1		4		1		1	2							
B	*Potamogeton amplifolius* Pondweed			2		2	3	4	3		1	4		1	2	3	4		4						
B	*Potamogeton obtusifolius* Pondweed						3	2	2	2		2		2		2			1						
	Nymphaea odorata Fragrant Water-lily			1													4								
A	*Sparganium angustifolium* Bur-reed	1	2	3	2	2	3	3	2	2	3	3	3	2	2	3	1		3	3	3	3	3	3	2
A	*Nuphar variegatum* Bullhead-lily	2		3	4	3	2	4	2		4	4	3	2	2	3	4	2	2	1	4	3	2	4	1
A	*Potamogeton berchtoldii* Pondweed		4	1		1	1	2	2		4	3	4	2	1	2			3	1	4	1		1	1
B	*Utricularia minor* Bladderwort	1		1	1	1					3		3	1	1						3				1
A	*Potamogeton natans* Pondweed			4	2	4	2	2	3		5	3	3	3	1	3	3	1	2		3				
B	*Eleocharis acicularis* Spike Rush			3								2	5		1					5					

TABLE 3. Submersed and floating-leafed aquatic plants in the 24 lakes (*concluded*).

	Holt	15 D	Grassy	7 A	Sawbill	Joeboy	Lizard	Gardner	7 B	1 B	1 A	24 A	Pickerel	Norwegian	13 A	Rita	Fern	15 A	Talus	Kay	Helen	Norma	Calcite	Legend
B *Scirpus subterminalis* Swaying Rush			2	2						5	1		1			3				5				
Myriophyllum alterniflorum Water Milfoil														2										
B *Utricularia intermedia* Bladderwort					1	2	2			2	1	3	1		1	1	1			3			2	
C *Potamogeton epihydrus* Pondweed									1		3	4			3		1		3	3	2	1	3	2
Sparganium minimum Bur-reed													2							1	2			
Sparganium fluctuans Bur-reed																							4	
Isoetes echinospora Quillwort														1										2
C *Potamogeton spirillus* Pondweed																			2		3	1		2

Note: Numbers indicate estimated percentage cover in areas of water depth < 2 m. 1: < 0.01% 2: 0.01-0.09% 3: 0.1-0.9% 4: 1-9% 5: ≥ 10%.
*Letters A, B, and C in front of plant names refer to a grouping of the species discussed in the text.
**Numbers at head of each column indicate total alkalinity of the lake water in ppm $CaCo_3$.

common in the lakes of low alkalinity but not the others: *Potamogeton spirillus* occurred in four of the six lakes of lowest total alkalinity but never above 40 ppm, while *P. epihydrus* was one of the most common pondweeds in several such lakes, and did not occur where total alkalinity was above 70 ppm. The remaining species were of limited distribution in the area, each occurring in fewer than four lakes.

Apart from the relationships of plant abundance to total alkalinity and associated measures, there were no obvious correlations between plant abundance and other aspects of water chemistry.

Sediment and shore type appeared to influence the occurrence of several species. Four species were largely confined to areas of mineral soil. *Callitriche palustris* was found rooted in clay or silty soils at the shallow edges of lakes and creeks. The seven lakes with *C. palustris* present had a lower percentage organic content in the sediment (mean ± SE of 28± 5) than the 17 other lakes (47 ± 4). *Eleocharis acicularis* was largely confined to silty and sandy soils, rather than clay or organic sediments. It was abundant only in lakes 24A, Talus, and Grassy. It formed a dense turf in areas where partly submerged tree stumps indicated that the lake bottom had once been forest soil. *Potamogeton gramineus* was the most common submersed plant in firm sand or gravel areas, usually on lakeshores and streambeds, but the species occurred occasionally on clay and soft organic sediments. *P. richardsonii* occupied sand and gravel sites.

Many species were largely confined to soft substrates. *P. amplifolius* and *P. natans* were usually found on soft organic sediments; *P. alpinus* and *P. epihydrus* on silt or organic sediments; *P. praelongus* and *P. zosteriformis* on clay or organic sediments; *P. foliosus* on clay, silt, and organic sediments. In several locations, *P. praelongus* occurred on 5–75 cm of organic sediments underlain by a firm stoney base. *Sparganium angustifolium* and *Nuphar variegatum* occurred both on soft substrates and on firm sand and gravel. *Najas flexilis* often occurred on soft organic sediments, frequently near a bog shore.

Field notes indicated typical water depths for a number of species. *Potamogeton gramineus* was usually found in 10–80 cm of water, *P. foliosus* in 30–90 cm, *P. zosteriformis* in 40–120 cm, *P. praelongus* in 40–150 cm, *P. amplifolius* in 60–150 cm, and *P. natans* in 100–150 cm.

Discussion

In previous work, there have been some differences in the use of the terms "soft" and "hard" water. Moyle (1945) uses "soft" to refer to water with a total alkalinity of <40 ppm $CaCO_3$, while Hellquist (1980) applies the term to water of 0–22 ppm $CaCO_3$ (0–18 mg/1 $HC0_3$). Thus, for example, Moyle (1945) lists *Pota-*

mogeton spirillus as a softwater species, while Hellquist (1980) considers it a plant of moderately alkaline water. We have adopted Moyle's division, of roughly 40 ppm, as it seems more useful in classifying the floras in our area (see also Fraser and Morton 1983).

With their comparatively high alkalinity, the lakes on Sibley Group rock included a number of typically hardwater species, plus a variety of species that tolerate a range of alkalinities. *Potamogeton pectinatus, P. strictifolius, P. richardsonii, P. praelongus*, and *P. amplifolius* are listed as hardwater species by Moyle (1945), together with *Myriophyllum exalbescens, Hippuris vulgaris, Najas flexilis*, and *Utricularia vulgaris*. Similarly, Swindale and Curtis (1957) included *Potamogeton pectinatus, P. richardsonii, P. zosteriformis* and *Myriophyllum exalbescens* in their category of plants with an affinity for alkaline water. In Moyle's (1945) study, a number of the species were typically found at >50 ppm sulphate. The lakes on our study all contained <15 ppm sulphate, indicating that high levels of sulphate are not specifically required by these species. In western Canada, *Potamogeton pectinatus, P. richardsonii, P. gramineus, Polygonum amphibium, Myriophyllum exalbescens, Utricularia vulgaris, Hippuris vulgaris* and *Eleocharis acicularis* have been reported in water of low to moderate salinity (Rawson and Moore 1944; Walker and Coupland 1970; Reynolds and Reynolds 1975). Evidently these species tolerate relatively high levels of dissolved solids. In addition, Rawson and Moore (1944) found *Potamogeton strictifolius* and *P. zosteriformis* in lakes of low salinity, but not in lakes with large amounts of dissolved solids.

The lakes with the lowest total alkalinity contained several typical softwater species. *Potamogeton spirillus, P. epihydrus*, and *Sparganium fluctuans* are listed as softwater species by Moyle (1945), and are common in other softwater Shield sites (Fraser and Morton 1983; Miller and Dale 1979; Crowder et al. 1977). *Isoetes echinospora* and *Sparganium minimum* also appear to be typical of soft water (Crowder et al. 1977; Moyle 1945).

Interestingly, three aquatic plants typical of Shield lakes were not found in the study area. *Lobelia dortmanna* (Water-lobelia), *Eriocaulon septangulare* (White buttons), and *Myriophyllum tenellum* (Water Milfoil) are common in softwater lakes elsewhere on the Shield in Ontario (Miller and Dale 1979; Fraser and Morton 1983). Data summarized by Crowder et al. (1977) indicate that at least the first two species occur in water with levels of dissolved minerals similar to those seen in Legend, Calcite, Norma, and Helen Lakes. Their absence from these sites may be due to geographic isolation as these lakes are located near the tip of the Sibley peninsula, about 25 km from the nearest granitic areas that might provide a source of these species.

Grazing by Moose had a substantial effect on aquatic vegetation in the area, as documented by Fraser and Hristienko (1983). In particular, the lakes most commonly used by Moose had little or no *Nuphar variegatum*, and several had an abundant growth of *Potamogeton foliosus*, probably because this species was able to colonize disturbed lake sediments. In addition, experiments have shown that the animals can reduce the abundance of preferred food species (e.g., *Potamogeton alpinus, P. epihydrus*) in areas of intense grazing (Aho and Jordan 1979; Fraser and Hristienko 1983). In the present study, *Potamogeton filiformis, P. amplifolius, P. strictifolius, Utricularia vulgaris, Scirpus subterminalis*, and *Myriophyllum exalbescens* were absent from the four small lakes (15D, 7B, 24A, and Talus) where Moose activity was heavily concentrated. This could be a direct effect of grazing, or repeated disturbance of the substrate by the animals may make it difficult for these species to become established.

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Food and Feeding Behavior of Sympatric Red-legged Frogs, *Rana aurora*, and Spotted Frogs, *Rana pretiosa*, in Southwestern British Columbia

LAWRENCE E. LICHT

Department of Biology, York University, 4700 Keele Street, Downsview, Ontario M3J 1P3

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The food and feeding behavior of *Rana aurora* and *Rana pretiosa* sympatric in marshes in southwestern British Columbia were studied. Newly metamorphosed and juvenile/adult frogs of each species were compared on the basis of frequency of occurrence of food type eaten and the abundance of each food type eaten. *Rana pretiosa* took more aquatic prey than *R. aurora* which fed more heavily on terrestrial prey types. Newly metamorphosed frogs had the highest inter-specific overlap (80%) in diet. *Rana pretiosa* feed predominantly in water, floating on the water surface or clinging to aquatic vegetation. On wet days only, *R. pretiosa* feed on land along the river margin or in or along rainpools. *Rana aurora* feed almost exclusively on land, along the river margin and in the vegetation.

Key Words: Frog food, frog feeding behavior, Red-legged Frog, *Rana aurora*, Spotted Frog, *Rana pretiosa*.

The Red-legged Frog, *Rana aurora aurora* and the Spotted Frog, *Rana pretiosa pretiosa*, are sympatric populations in southwestern British Columbia. The discovery in 1967 of coexistence of these two closely related species prompted investigation of their comparative biology. Their feeding behavior (Licht 1969a, 1969b), embryonic temperature adaptations (Licht 1971) and population dynamics (Licht 1974) have been described and reports on their comparative morphology, physiology and ecology are in preparation.

An important component of successful coexistence between closely related species is how they share available resources (e.g. Lack 1945; MacArthur 1958; Tanner 1966; Sale 1974). An axiom of ecology is that competitive exclusion may result if the niche requirements of related species are too similar (Gause 1934). Description of food and feeding behavior is essential to comparative ecological studies, since overlap in diets and foraging strategies may indicate potential species-limiting competitive interactions (Schoener 1971).

I examined the food eaten by sympatric *R. aurora* and *R. pretiosa* and studied their feeding behavior in the field and laboratory in order to evaluate the importance of feeding habits in maintaining ecological separation between the species.

Study Area

Both species occur in marshes about 9 km east of White Rock, British Columbia (49°02′N, 122°39′W). A seven-acre field, and adjacent marshes, about 70 m above sea level, were used as the sites of field studies.

The area is wet flat lowland, covered predominantly by bulrushes (*Juncus effusus*), sedges (*Carex* sp.), and buttercups (*Ranunculus repens*). *Ranunculus* forms nearly a complete carpet throughout the field. The other two plant types are abundant but scattered throughout the whole area. The eastern and western borders of the field are alder, birch, and coniferous woods, the southern border is more lowland marsh, and the northern side is interrupted by an asphalt road, beyond which is more marsh.

A permanent slow-moving stream, the Little Campbell River, flows through the centre of the field. The river margins fluctuate considerably during the spring rains, from February through April, and the width may vary from 2 to 30 m in a few days. In wet periods during the spring, the shallow overflow is usually not more than 1 m deep, and after several days without rain this overflow subsides, leaving the main channel about 1–5 m wide. The channel depth varies from 0.5–2 m in the centre, to 0.2–8 m on the gradually sloping edges. There is little current in the river except after heavy spring rains.

The river bottom is soft mud covered by rotting vegetation. During the summer the river is low and is filled with a dense growth of Spatterdock (*Nuphar luteum*), duckweed (*Lemna* sp.), pondweed (*Potamogeton* sp.), and watermilfoil (*Miriophyllum* sp.). *Carex, Juncus*, cattails (*Typha latifolia*), and *Ranunculus* grow profusely along the banks, but the continuously fluctuating river level usually leaves a strip of exposed mud along the river course.

After a day or more of rain during the spring, numerous rainpools dot the field. These pools vary in area from small puddles to larger pools about 1 m². At times, channels form from the large pools to the river. The pools are less than 8–12 cm deep with a soft mud

bottom. They tend to reform in the same low places within the field. They remain filled for several weeks during the spring, but by June, with warm weather and less rain, they dry up. With heavy summer rains they may refill, but dry again after a few days. By September, the pools are again filled with the onset of autumn rains, and they persist throughout the winter.

Methods

Food and Feeding Behavior

From May to October, 1968, frogs were collected from marshes for analysis of their stomach contents. Frogs of both species were caught on the same days, and they were often taken in the same vicinity, sometimes less than 1 m apart, so that the food in their intestinal tracts represented prey items that were potentially available to both species.

I walked along the river margins and through the vegetation and attempted to catch all frogs seen. After capture, each frog was killed and preserved in a 5% formalin solution. At a later date, the entire intestinal tract was removed from each specimen and all animal remains were identified. All insect remains were identified, when possible, to family level (with the exception of Plecoptera and Tricoptera), and to growth stage (adults or larvae). All spiders were listed as arachnids and not classified further. Only two kinds of molluscs were eaten: slugs and snails. They are listed as such.

I obtained two kinds of data: the frequency occurrence of a particular type of food which is derived from the number of stomachs in each frog group which contained that particular food item, and the abundance of a particular food item which is the total number of that particular item in all stomachs containing it. Each species was divided into two groupings: newly metamorphosed frogs of the season (28–33 mm snout vent length (SVL), and frogs 1-year old (juvenile) and older (> 40 mm SVL). Each group was treated separately, and differences between sexes were not examined.

The primary aim of stomach analysis was to determine the degree of overlap in food items taken by the two species. For one means of comparison, all food items were tabulated and the ratio of the number of food types shared between the two species (and age groups within and between species) over the total number of food types for each species, × 100, yielded the percentage overlap. An overlap measure was calculated for comparison between each frog group. A similar method of determining percentage overlap in diet has been used to compare sympatric bird species (Holmes and Pitelka 1968) and sympatric lizards (Rose 1976).

Attention was given to the food types most heavily represented in the diet. The dominant food items in the diet of each species were calculated in two ways: the eight food items that occurred in most stomachs of each frog group (frequency occurrence) regardless of their abundance in the stomach (Figure 1), and the eight food items that were most abundant in all stomachs within each frog group (Figure 2). These eight items represented over 50% (by abundance) of all food items eaten by each frog group.

Natural feeding behavior

I occasionally used binoculars or my unaided eye to observe the feeding behavior of frogs that were unaware of or, at least, not obviously frightened by me. I watched their movements and orientation response to nearby prey. Of special importance was the type of substrate that feeding activities occurred on and the general hunting patterns of the frogs. At times I threw certain food items to frogs and watched their behavior. These casual observations allowed only qualitative description of feeding activities.

Laboratory feeding tests

Newly metamorphosed frogs which had been laboratory raised from eggs were kept in glass stacking dishes. These frogs were fed *Drosophila* and general observation of the feeding patterns of the frogs under wet and dry conditions were recorded.

Morphology

The snout-vent length and head width of a series of frogs of both species were measured. The SVL was measured to the nearest mm and for the same individual the width of the head (at the posterior angle of the jaws midway across tympanum) was measured to the nearest 0.1 mm. The method for head width measurement follows Dunlap (1955).

The extent of webbing and position of the eyes, both features related to feeding, were also compared.

A series of *R. pretiosa* (NMC 25851–25862) and *R. aurora* (NMC 25863–25875) are on deposit in the National Museum of Natural Sciences (Herpetology Section), Ottawa, Canada.

Results

Feeding behavior in the field

Adult and juvenile *R. aurora* are quite secretive and were rarely sighted until they began jumping as I neared them in my searches of the field. I was unable to make meaningful observations of their natural feeding behavior.

The feeding behavior of newly transformed *R. aurora* was more easily observed. After metamorphosis in July, the small frogs remain along the river banks. They are usually found within 1 m of the river edge in patches of *Ranunculus* that grow along the shore. On warm dry days during the summer, they feed at the

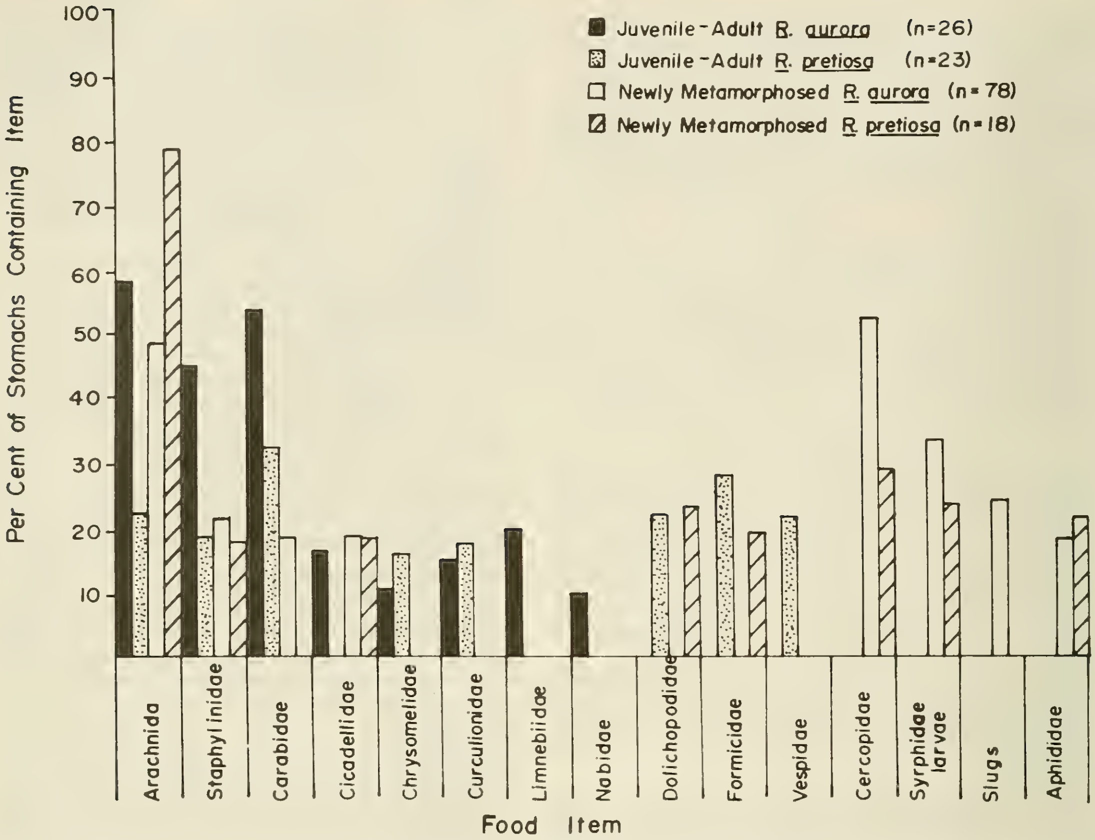

FIGURE 1. Comparison of dominant food items of frogs of different age classes, and percentage of total stomachs which contained the food type. Top eight items for each age class are those appearing in most stomachs within each class (see text). Number in parentheses is total number of stomachs for each age class within each species.

water margin, catching small insects along the banks, in the vegetation, and occasionally swimming a few cm into the river to take an insect on the water surface or on an aquatic plant. In the early part of the day when there is still moisture left on the vegetation, the small *R. aurora* move the vegetation and feed in the undergrowth.

During or after a rain, small *R. aurora* move many m from the river, on the carpet of *Ranunculus* and near stands of *Carex*, trying to catch spiders and small insects. If rainpools form in the field, the frogs feed along their margins, stalking small prey in and out of the water. They often remain in the vicinity of the rainpools as long as the pools contain water, but once these dry, the frogs again return to the river margins.

Although I did not observe feeding behavior in adult *R. aurora*, individuals were often startled as I walked along the river or into the vegetation. Presumably they were feeding in the vegetation along the river margins, as were the young-of-the-year. Adults were also found many m away from the river usually hidden in dense moist patches of *Ranunculus*. *Rana aurora* were never seen in the river channel proper.

The natural feeding behavior of young and adult *R. pretiosa* is easily observed. Individuals were usually seen from far enough away that I was able to observe them without disturbing them.

Throughout the year, *R. pretiosa* feed in or along bodies of water, either the river, pond, or rainpools when present. During May and early June, when rainpools form in the field, *R. pretiosa* feed along the sides of these pools, or while floating on the water surface. During the summer, when rainpools are dry, the frogs float in the river, hanging onto stems or other vegetation, either in mid-stream or at the river margins. Often they are completely submerged except for their heads that protrude above the water. They often remain half concealed in thick beds of *Potamogeton* or *Myriophyllum*. Depending on the temperature, they may also sit on exposed mud along the river

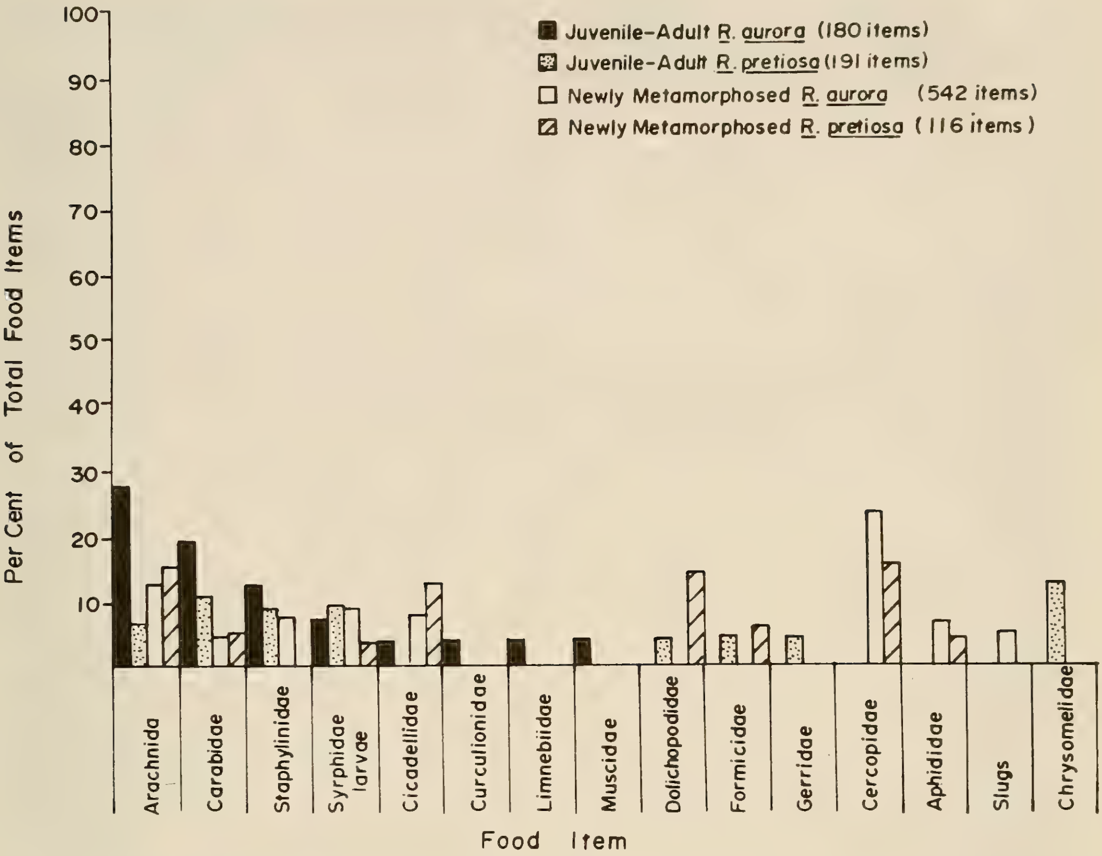

FIGURE 2. Comparison of dominant food items of frogs of different age classes, and percentage of total food intake each food item comprises. Top eight items are those most abundant in all stomachs of each age class (see text). Number in parentheses is total number of all food items found in stomachs of each group of both species.

margins, and as the temperature rises they move into the water.

R. pretiosa remain motionless for long periods, sometimes for an hour or more. Any suitable prey that moves near them evokes an orientation response, and if the prey is close, the frog strikes at it. Usually a prey is located on the water surface, and the frog swims towards it, kicking with the hind limbs and making little disturbance. Usually only the head and eyes of the frog protrude above the water. After stalking the prey in this manner, *R. pretiosa* strike from close range.

On dry days, *R. pretiosa* are rarely found out of water. At most they are within 0.5 m of the water. On dry days, I saw no feeding activity on land. However, during and after rain, these frogs move into the wet undergrowth and feed among the vegetation, sometimes many m from the river. They quickly move into rainpools when these form in the field and feed from the water surface or margins. When rainpools dry, they return to the river.

Newly transformed frogs of both species are often seen feeding within cm of each other, usually along the river edge or near rainpools. On hot summer days, when *R. aurora* are found along the river margins, the two species often feed in close proximity. However, on such occasions, *R. pretiosa* are almost always in the water, while *R. aurora* are on the nearby land. *R. aurora* are presumably more active in seeking food and move in and out of the vegetation; *R. pretiosa* spend more time waiting for prey to move near.

Both species are diurnal in feeding habits, but may feed at night during warm summer nights. I did not observe nocturnal activities but frogs of both species were caught at night.

I threw various food items to adult *R. pretiosa* to note their responses. Small grasshoppers and other small prey were readily taken if the prey were thrown

TABLE 1. Analysis of food items in gut contents of *Rana aurora*. Data are for newly metamorphosed (nm), juvenile/adult (ja) and both combined (c). Numbers in parentheses are total stomachs and total food items for each age group.

Food items	% of all stomachs nm (78)	ja (26)	c (104)	% of total food items nm (542)	ja (180)	c (722)
Mollusca						
Snail	3.8	3.8	3.8	1.8	0.6	1.5
Slug	23.1	3.8	18.3	5.2	0.6	4.0
Arachnida	48.7	57.7	51.0	12.0	26.7	15.6
Insecta						
Orthoptera						
Locustidae	1.3	—	1.0	0.2	—	0.1
Plecoptera	1.3	—	1.0	0.2	—	0.1
Hemiptera						
Gerridae	1.3	7.7	2.9	0.2	1.1	0.4
Nabidae	5.1	11.5	6.7	0.7	2.2	1.1
Saldidae	6.4	7.7	6.7	1.1	1.1	1.1
Miridae	—	3.8	1.0	—	0.6	0.1
Cercopidae	52.6	7.7	41.3	22.9	1.7	17.6
Cicadellidae	17.9	15.4	17.3	7.7	3.3	6.6
Aphididae	16.7	3.8	13.5	5.7	1.1	4.6
Coleoptera						
Carabidae adult	16.7	53.8	26.0	4.1	17.8	7.5
Carabidae larvae	3.8	7.7	4.8	1.3	1.1	1.2
Dytisicidae	1.3	—	1.0	0.2	—	0.1
Limnebiidae	—	19.2	4.8	—	3.3	0.8
Staphylinidae	20.5	46.2	26.9	6.5	12.8	8.0
Staphylinidae larvae	2.6	—	1.9	0.6	—	0.4
Phalacridae	2.6	—	1.9	0.4	—	0.3
Coccinellidae	—	3.8	1.0	—	0.6	0.1
Lampyridae larvae	—	3.8	1.0	—	0.6	0.1
Elateridae larvae	1.3	—	1.0	0.2	—	0.1
Scarabaeidae	2.6	—	1.9	0.6	—	0.4
Chrysomedlidae	7.7	11.5	8.7	1.8	1.7	1.8
Mylabridae	—	3.8	1.0	—	0.6	0.1
Curculionidae	2.6	15.4	5.8	0.4	3.3	1.1
Trichoptera adult	2.6	7.7	3.8	0.4	1.1	0.6
Trichoptera larvae	1.3	3.8	1.9	0.2	1.1	0.4
Lepidoptera						
Geometridae larvae	—	3.8	1.0	—	0.6	0.1
Noctuidae larvae	1.3	7.7	2.9	0.2	1.1	0.4
Diptera						
Tipulidae adult	1.3	7.7	2.9	0.2	1.1	0.4
Tipulidae larvae	3.8	—	2.9	0.7	—	0.6
Chironomidae larvae	11.5	—	8.7	3.1	—	2.4
Cecidomyiidae	1.3	—	1.0	0.2	—	0.1
Mysetopliidae	2.6	—	1.9	0.4	—	0.3
Otitidae	1.3	—	1.0	0.2	—	0.1
Stratiomyidae larvae	1.3	—	1.0	0.2	—	0.1
Dolichopodidae	6.4	3.8	5.8	2.3	1.1	1.9
Ephydridae	5.1	—	3.8	1.4	—	0.8
Syrphidae larvae	32.1	3.8	25.0	7.5	6.1	7.5
Canopidae	—	3.8	1.0	—	0.6	0.1
Bibionidae	—	3.8	1.0	—	0.6	0.1
Trupaneidae	2.6	—	1.9	0.6	—	0.4
Muscidae	1.3	3.8	1.9	0.2	3.3	1.0
Borboridae	3.8	—	2.9	0.6	—	0.4
Hymenoptera						
Tenthredinidae	1.3	3.8	1.9	0.2	0.6	0.3
Tenthredinidae larvae	3.8	—	2.9	0.6	—	0.4

TABLE 1. Analysis of food items in gut contents of *Rana aurora* (*concluded*).

Food items	% of all stomachs nm (78)	ja (26)	c (104)	% of total food items nm (542)	ja (180)	c (722)
Ichneumonidae	14.1	7.7	12.5	4.1	1.1	3.6
Braconidae	1.3	—	1.0	0.2	—	0.1
Chalcididae	2.6	—	1.9	0.7	—	0.6
Cynipidae	3.8	—	2.9	0.6	—	0.4
Trichogrammatidae	—	3.8	1.0	—	0.6	0.1
Formicidae	10.3	3.8	8.7	1.5	0.6	1.2
Total				100	100	100

TABLE 2. Analysis of food items in gut contents of *Rana pretiosa*. Data are for newly metamorphosed (nm), juvenile/adult (ja) and both combined (c). Numbers in parentheses are total stomachs and total food items for each age group.

Food items	% of all stomachs nm (18)	ja (23)	c (41)	% of total food items nm (116)	ja (191)	c (307)
Mollusca						
Snail	—	8.7	4.9	—	2.1	1.3
Slug	—	4.3	2.4	—	0.5	0.3
Arachnida	77.8	21.7	22.0	14.7	4.7	8.5
Insecta						
Orthoptera						
Locustidae	—	4.3	2.4	—	0.5	0.3
Odonata						
Coenagrionidae	—	8.7	4.9	—	1.0	0.7
Hemiptera						
Corixidae adults	—	4.3	2.4	—	0.5	0.3
Corixidae nymphs	—	4.3	2.4	—	0.5	0.3
Gerridae	5.6	13.0	9.8	0.9	3.7	2.6
Nabidae	11.1	8.7	9.8	1.7	1.6	1.6
Saldidae	11.1	8.7	9.8	1.7	1.0	1.3
Cercopidae	27.8	8.7	17.1	14.7	1.0	6.2
Cicadellidae	16.7	8.7	12.2	12.9	1.0	5.5
Aphididae	22.2	13.0	17.1	4.3	2.6	3.3
Coleoptera						
Carabidae	11.1	26.1	19.5	4.3	9.9	7.8
Carabidae larvae	—	4.3	2.4	—	1.0	0.7
Dytiscidae	11.1	13.0	12.2	1.7	1.6	1.6
Staphylinidae	16.7	17.4	17.1	3.4	7.3	5.9
Hydrophilidae larvae	—	4.3	2.4	—	0.5	0.3
Coccinellidae	11.1	—	4.9	1.7	—	0.7
Coccinellidae larvae	5.6	4.3	4.9	0.9	1.0	1.0
Cantharidae	—	4.3	2.4	—	0.5	0.3
Heteroceridae	5.6	—	2.4	1.7	—	0.7
Buprestidae	—	13.0	7.3	-	2.1	1.3
Haliplidae	—	4.3	2.4	—	0.5	0.3
Meloidae	—	4.3	2.4	—	1.0	0.7
Nitidulidae	5.6	—	2.4	1.7	—	0.7
Scarabaeidae	—	4.3	2.4	—	0.5	0.3
Chrysomelidae	5.6	17.4	12.2	1.7	13.6	9.1
Chrysomelidae larvae	—	4.3	2.4	—	3.7	2.3
Curculionidae	5.6	17.4	12.2	0.9	2.1	1.6
Trichoptera adult	—	4.3	2.4	—	0.5	0.3
Trichoptera larvae	—	4.3	2.4	—	0.5	0.3
Lepidoptera						
Hepialidae larvae	—	4.3	2.4	—	0.5	0.3
Noctuidae larvae	5.6	—	2.4	0.9	—	0.3

TABLE 2. Analysis of food items in gut contents of *Rana pretiosa* (*concluded*).

	% of all stomachs			% of total food items		
Food items	nm (18)	ja (23)	c (41)	nm (116)	ja (191)	c (307)
Pieridae larvae	—	4.3	2.4	—	0.5	0.3
Diptera						
Tipulidae	—	8.7	4.9	—	1.6	1.0
Chironomidae larvae	5.6	—	2.4	0.9	—	0.3
Cecidomyiidae	11.1	—	4.9	1.7	—	0.7
Lauxaniidae	—	4.3	4.9	—	1.0	0.7
Dolichopdidae	22.2	21.7	22.0	13.8	4.2	7.8
Ephydridae	5.6	8.7	7.3	1.7	1.0	1.3
Syrphidae adult	22.2	4.3	2.4	3.4	1.0	0.7
Syrphidae larvae	—	13.0	17.1	—	8.4	6.5
Bibionidae	—	8.7	4.9	—	2.6	1.6
Tachnidae	5.6	8.7	7.3	0.9	2.1	1.6
Hymenoptera						
Ichneumonidae	5.6	4.3	4.9	0.9	0.5	0.7
Vespidae	5.6	21.7	14.6	0.9	3.1	2.3
Formicidae	16.7	26.1	22.0	6.0	3.7	4.6
Bombidae	—	4.3	2.4	—	0.5	0.3
Apidae	—	13.0	7.3	—	2.6	1.6
Total:				100	100	100

near the frogs in the water. On many occasions, a frog would seize a prey item and then quickly submerge its head to swallow. Occasionally, a frog came onto the river bank to take a prey item I had thrown, but always returned immediately to water and often submerged to swallow the food. These frogs seemed reluctant to move onto land to take food, although they would swim to shore and investigate food items thrown onto shore.

Rana pretiosa (55–75 mm SVL) seized and ate adult Pacific Tree Frogs, *Hyla regilla* (30–35 mm SVL), and small *R. aurora* and *R. pretiosa* (27–35 mm SVL). Three times, without any manipulation on my part, I saw adult *R. pretiosa* grab and attempt to swallow newly metamorphosed *R. aurora*. In two of these cases, the *R. pretiosa* swallowed the prey, but the third frog escaped by struggling violently. Adult *R. pretiosa* often oriented to small *R. aurora* moving on land, but they did not leave the water.

In laboratory terraria, adult *R. aurora* jump readily and with accuracy a foot or more in attempting to catch a prey item. *Rana pretiosa* seldom jump, but move slowly towards a prey item and seize it directly, or jump from a few cm away. *Rana pretiosa* sometimes jump many times in succession at a prey, and often trip with awkward jumping motions.

Analysis of stomach contents

From May to October 1968, 104 *R. aurora* and 41 *R. pretiosa* were collected and their gut contents analyzed fof food items. Each sample was separated into two categories: 78 newly transformed *R. aurora*; 26 juvenile/adult *R. aurora*; 18 newly transformed *R. pretiosa*; 23 juvenile/adult *R. pretiosa*. Newly metamorphosed frogs first appear in samples taken in July and August.

No frog had an empty stomach. The food taken by newly metamorphosed, juvenile/adult and both groups combined, for *R. aurora* is listed in Table 1. The food eaten by the same groups for *R. pretiosa* is listed in Table 2.

The number of food classifications and the percentage overlap of these food classifications between species and age groups within species is presented in Table 3.

Another means of judging the degree to which both species, and age groups within species, share the same resources is to examine the dominant foods appearing in their gut contents. If foods that are used more frequently by each species are shared, competitive interaction between the species may be probable. The dominant foods were determined in two ways, described previously.

The top eight foods based on their abundance in the guts of frogs in the different samples make up over 50% of the food eaten. For all *R. aurora* the top eight foods comprise 71.4% of all the food, and for all *R. pretiosa*, the top eight foods comprise 57.3% of total food items eaten. For age classes within species, the dominant eight foods make up the following percentages of all food eaten: newly metamorphosed *R. aurora* — 72%, juvenile/adult *R. aurora* — 76%, newly metamorphosed *R. pretiosa* — 74%, juvenile/adult *R. pretiosa* — 55.5%.

A comparison of the percentage overlap of the dom-

TABLE 3. Matrix of percentages of food overlap between age groups, within and between species. N = total stomachs (number in parentheses is total number of food types within the sample). NM = newly metamorphosed. J/A = juvenile/adult.

		*Rana aurora**		*Rana pretiosa***	
		NM N = 78 (44)	J/A N = 26 (33)	NM N = 18 (25)	J/A N = 23 (44)
R. aurora	NM	—	69.7	80.0	55.8
	J/A	51.1	—	65.4	48.8
R. pretiosa	NM	45.5	51.5	—	43.2
	J/A	53.3	63.6	76.0	—

*All *R. aurora* combined exploited 53 food types and share 56.6% with all *R. pretiosa*.
**All *R. pretiosa* exploited 50 food types and share 60% with all *R. aurora*.

inant eight food classes based on their frequency of occurrence in stomachs of the sample and on their total numbers in all stomachs is listed in Table 4. The value 75% in Table 4 is striking. This means that newly metamorphosed frogs of both species share 75% of the foods which occurred most frequently in stomachs and, as well, they share 75% of the prey items that were eaten in greatest abundance. If both age groups within each species are combined, then the species share 75% of the dominant foods occurring most frequently and 75% of the food types eaten in greatest numbers.

The dominant eight food types occurring most frequently in the stomachs of the different age groups of both frog species are seen in Figure 1. The dominant eight food types eaten in greatest numbers by all age groups are seen in Figure 2.

Laboratory feeding tests

In dry bowls, 39% of the strikes by *R. aurora* and 42% of those by *R. pretiosa* were successful. In wet bowls, each species showed about 25% strike success.

In bowls with water, the newly metamorphosed *R. pretiosa* struck almost exclusively at flies that were on the water surface and seldom attempted to catch flies on the cover or walls of the bowl. In contrast, *R. aurora* tried for flies on the covers and walls and not those on the water surface. In both wet and dry conditions, *R. pretiosa* struck at flies more often than did *R. aurora*.

Morphology

The head width of 26 *R. pretiosa* (31–72 mm SVL) and 40 *R. aurora* (27–74 mm SVL) was significantly correlated with body size for each species. For *R. pretiosa* where y = head width and X = SVL, the regression analysis is $y = 0.4071 + 0.3299X$ ($r = 0.98$). For *R. aurora*, $y = 0.2916 + 0.3472X$ ($r = 0.99$).

In order to compare species, the ratio of head width/SVL was determined following the method of Dunlap (1955) who studied allopatric *R. aurora* and *R. pretiosa* in Oregon. For *R. aurora* the mean head width/SVL ratio was 35.52 with a range of 32.41 to 38.61. For *R. pretiosa* the mean was 33.94 (range of 31.91 to 38.54). The head width/SVL between species differed significantly (Student t-test, $P < 0.001$). In Oregon (Dunlap 1955) for *R. aurora* head width/SVL averaged 35.93 for males and 36.88 for females. In Oregon, *R. pretiosa* males averaged 36.19 and females averaged 35.38. In Oregon the head width between *R. aurora* and *R. pretiosa* did not differ significantly (Dunlap 1955).

Rana pretiosa have webbing which more extensively covers the digits of their hind limbs. An indication of this relative difference in webbing is seen by measuring the portion of the fourth, or longest, digit on the hind foot extending beyond the webbing. For example, a *R. pretiosa* 32 mm SVL had the fourth digit extending 2.3 mm beyond the webbing; a *R. aurora* of the same size had 5.0 mm of the digit free of webbing. A 68 mm *R. pretiosa* had 8.9 mm web free digit and a 66 mm *R. aurora* had 12.0 mm free. The same pattern is consistent with 66 other individuals measured.

In addition *R. pretiosa* have eyes which face dorsally; those of *R. aurora* face laterally. *Rana pretiosa* can have their heads nearly submerged with their eyes above water. *Rana aurora* would have their eyes under water, when submerged to the same depth as *R. pretiosa*.

Discussion

The key to the successful coexistence of *R. aurora* and *R. pretiosa* probably is their distinct habitat preferences. A full report on their comparative ecology will be presented elsewhere but here it is sufficient to state that *R. pretiosa* show an affinity for water and *R. aurora* prefer land for all non-breeding behavior. The morphology, ecology, physiology and behavior of the frogs are all linked to these preferences. For example, the eye placement and degree of webbing on the hind

TABLE 4. Matrix of percentages of food overlap of dominant eight foods ranked by frequency and abundance*. NM = newly metamophosed. J/A = juvenile/adult.

		% shared *Rana aurora*				% shared *Rana pretiosa*			
		NM		J/A		NM		J/A	
		freq.	abun.	freq.	abun.	freq.	abun.	freq.	abun.
Rana aurora	NM		–	—	—	–	—	—	—
	J/A	50.0	62.5	—	—	—		—	
Rana pretiosa	NM	75.0	75.0	37.5	50.0	–	—	—	—
	J/A	37.5	50.0	62.5	50.0	50.0	62.5	—	—

*All *R. aurora* combined and all *R. pretiosa* combined share 75% of dominant eight foods ranked by frequency, and 75% ranked by abundance.

feet of *R. pretiosa* are both adaptations for a more aquatic behavior than *R. aurora*. These same morphological differences between *R. aurora* and *R. pretiosa* have been noted by Stebbins (1951) and Dunlap (1955).

The two species are normally separated by their land or water preference. *Rana aurora* feed predominantly on land, along the river bank or margins of rainpools, moving within the plant cover. *Rana pretiosa* feed almost exclusively in or next to water. The lab tests on feeding behavior indicated that *R. pretiosa* feed on prey from a water surface more readily than *R. aurora*. In spring and autumn, when rainpools are filled, the frogs may feed closer to each other than at other times. In general however, the food eaten reflects the divergence in feeding sites in that *R. pretiosa* take more aquatic prey organisms than does *R. aurora*. A good argument for this view is that, for example, terrestial land slugs are taken frequently by *R. aurora* and infrequently by *R. pretiosa*. In contrast, *R. pretiosa* feed on Dolichopodidae, Corixidae, Gerridae and Dytiscidae, all aquatic prey which are not eaten frequently by *R. aurora*. Schonberger (1945) and Turner (1959) also found a variety of aquatic prey items in the diet of *R. pretiosa* not in sympatry with *R. aurora*.

Rana aurora and *R. pretiosa* are virtually identical in size. In lowland British Columbia, *R. aurora* metamorphose at 27–29 mm SVL, males reach a maximum SVL of 64 mm and females 76–78 mm in 3 to 5 years. *R. pretiosa* in the field metamorphose at 30–33 mm SVL and reach the same maxima in the same time as *R. aurora* (Licht 1974). (However, in Wyoming, *R. pretiosa* differ in size from those in lowland British Columbia (Turner 1958, 1960; Licht 1975)).

In Oregon the head width of these two species does not differ (Dunlap 1955), but in British Columbia the head width of *R. aurora* tends to be somewhat larger than that of *R. pretiosa*. A study of possible character displacement in areas of sympatry is warrented. Presumably the full extension of the jaws, or gape, is correlated with the head width such that, theoretically *R. aurora* could take slightly larger prey than *R. pretiosa*. Sizes of prey taken by frogs were not measured so the possibility of larger prey taken by *R. aurora* cannot be refuted or substantiated.

No detailed study of the availability of prey species was done, so no conclusive statement can be made regarding the possibility of food selection or prey preferences by either *R. aurora* or *R. pretiosa*. Very likely, any available food is taken. For example, arachnids are available in all months from May-October and they appear in guts in all samples. Syriphid flies and larvae first become abundant in samples from July and August, the time when flies are especially numerous in the field. In other studies on ranid feeding behavior frogs were found to take whatever prey were available, not showing distinct food preferences (Frost 1935; Schonberger 1945; Turner 1958; Korschgen and Baskett 1963; Linzey 1967; Hedeen 1972; Kramek 1972).

Studies on other ranid species in sympatry have shown that ranids are opportunistic feeders and frogs of the same size class in the same general habitat have very similar diets (Marshall and Buell 1955; Inger and Greenberg 1966; Hedeen 1972).

If competition is understood to be the demand for a resource in limited quantities (Tanner 1966; Miller 1967; Sale 1974), there is little likelihood of competition over food in the study area where *R. aurora* and *R. pretiosa* are sympatric. Sale (1974) pointed out that when resources are not limiting to population growth, patterns of resource use may overlap to any degree. For example, newly metamorphosed frogs of both species shared 75% of dominant food types by frequency of occurrence and 75% by abundance. Yet the fields and marshes where the frogs live are rich in

diversity of habitats suitable for a wide range of prey organisms available to both species. The availability and abundance of food are indicated by the fact that not a single frog of 145 examined was without food in its stomach. Moreover no frog caught during the study appeared weak or unhealthy (except for a single blind small *R. aurora*). In laboratory tests, frogs that had never eaten food after metamorphosis were able to survive over one month without eating. Thus, should a scarcity of food arise, an unlikely situation in the study area, frogs of both species could withstand food limitations for many days.

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Aspects of Reproduction of the Fisher, *Martes pennanti*, in Manitoba

RICHARD D. LEONARD

Department of Zoology, University of Manitoba, Winnipeg, Manitoba R3T 2N2
Present address: Parks Canada, Prairie Region, Confederation Building, 4th Floor, 457 Main Street, Winnipeg, Manitoba R3B 3E8

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During March and April, 1976 and 1977, aspects of reproduction of Fishers (*Martes pennanti*) were studied in the field by use of radio-telemetry, tracking, and track observations. Information on male and female reproduction was gathered from analysis of 195 trapper-caught Fisher carcasses collected from four areas of Manitoba during the winters of 1972-73 to 1977-78. Presence of pregnant females in the yearling age class, increased tract volume and follicular development of late-winter juveniles, and observation of a tract of a recently-bred juvenile female indicated that first estrus of females occurred at the end of the first year of age. Winter maturation of testes followed a similar pattern for juveniles and adults. All males tested in March were spermatic, but none was spermatic earlier in winter. Weights of bacula from juveniles increased during winter and by March approached the range of bacula weights of adults. Estrus and parturition occurred in late March and April. Uniform development of early-winter juveniles suggested that a restricted whelping period and possibly a restricted mating period occurred for all ages of reproducing females. The mean and mode corpora lutea counts for pregnant females were 3.5 and 3, respectively. Age-related fertility rates appeared to exist. Indices of fertility and productivity remained relatively constant from 1972 to 1978, suggesting that no significant time-specific changes in reproduction occurred. Reproductive characteristics of Fishers from Manitoba differed little from those reported from other regions within the species' geographic range. Observations of maternal behavior and physical characteristics of captive-born and wild-born kits are presented. Radio-telemetry and tracking evidence during the mating period suggested that adult females in or approaching estrus remained sedentary. Males moved extensively to seek out females in estrus and intrasexual spacing mechanisms among males appeared to break down. No male–male physical interactions were observed in the field, but the presence of minor skull injuries in breeding-age males implied that some form of interaction could occur. All available evidence supports the presence of a promiscuous breeding system in Fishers.

Key Words: Fisher, *Martes pennanti*, reproduction, breeding systems, Manitoba.

Excessive harvest by the fur industry resulted in a significant reduction in the distribution and abundance of the Fisher throughout most of its range. By the 1940s Fisher populations were restricted to remote areas of poor access (Hall 1942; Rand 1944; Hagmeier 1956). The species made a rapid recovery after protection measures were enforced (Cook 1950; Hamilton and Cook 1955; Benson 1959; Coulter 1960; Balser and Longley 1966; Dodds and Martell 1971; Yocum and McCollum 1973; Dilworth 1975; Cottrell 1978) and reintroductions were carried out (Bradle 1957; Kebbe 1961; Morse 1961; Irvine et al. 1964; Weckwerth and Wright 1968; Pack and Cromer 1981). The Fisher has become redistributed throughout much of its historical range in Canada (Strickland and Douglas 1981). At present, population densities are sufficient to sustain a harvest in many jurisdictions. An adequate knowledge of reproduction in the Fisher is required by managers to establish sensible harvest quotas to minimize the occurrence of population decline, an event which has recently been shown to remain a distinct possibility (Powell 1979a).

Early work on fur farms demonstrated that female Fishers enter estrus shortly after parturition and remain pregnant for nearly a year (Hall 1942). Enders and Pearson (1943) positively showed that delayed implantation of blastocysts was the reason for this unusually long period of pregnancy. Reproduction in wild populations has not been studied throughout the bulk of the Fisher's geographic range. Eastern areas such as New York (Hamilton and Cook 1955; Eadie and Hamilton 1958), New Hampshire (Kelly 1977), Maine (Coulter 1966; Wright and Coulter 1967) and Southern Ontario (Strickland and Douglas 1981) have received the most attention, although many unpublished accounts by fur harvest managers from other regions undoubtedly exist. Coulter (1966) and Wright and Coulter (1967) provided the most comprehensive information on reproduction and growth of the Fisher by studying male and female reproductive tracts and skeletons, growth of captive kits, changes of activity of the Fisher in the field during the mating period, and other relevant details. However, studies on reproduction are lacking from the major portion of the Fisher's range, which comprises a broad belt of primarily coniferous forest across Canada. In this boreal environment factors

such as prey base, weather and effect of snow cover (Leonard 1980; Raine 1983) differ markedly from the aforementioned eastern areas and could result in an expression of different reproductive characteristics. Above all, no studies from any area described the movements of marked individuals during the mating period.

The purpose of this study was threefold: (a) to determine if reproductive characteristics of a northern Fisher population differed from those of better-studied eastern areas, (b) to gain information on movements and behavior during the mating period, and (c) to present a hypothesis on the type of breeding system of the Fisher based on new and existing information.

Study Areas

Extensive Study Areas

Four areas in Southern Manitoba were selected for collection of Fisher carcasses (Figure 1). The East Lake Winnipeg, Whiteshell, Southeast and West extensive study areas all lie in the Boreal Forest Region (Rowe 1972). In all except East Lake Winnipeg, Fishers were extirpated or reduced to extremely low densities due to overharvest, but have recently made a numerical come back. Fishers are trapped in all four areas, a factor which is likely important in affecting densities. Each area differs in terms of land use practices related to forestry and wildlife management.

Intensive Study Area

The intensive study area is located in the East Lake Winnipeg extensive study area (Figure 1). The Taiga Biological Station (51°02′41″N., 95°20′40″W.) was used as the main camp for field studies. Pleistocene glaciation exposed irregular, parallel ridges of Precambrian granites and gneisses (Russell 1948). Dominant features between ridges are peat development, shallow lakes, glacial outwash sandplains, and sporadic glacial drift. The area is classed in the Northern Coniferous Section of the Boreal Forest Region (Rowe 1972). Relatively dry upland sites are dominated by Jackpine (*Pinus banksiana*), White Spruce (*Picea glauca*), Black Spruce (*Picea mariana*), Balsam Fir (*Abies balsamea*), Birch (*Betula papyrifera*), Trembling Aspen (*Populus tremuloides*), and Balsam Poplar (*Populus balsamifera*). Thick Black Spruce and Alder (*Alnus* spp.) stands are predominant in most lowland sites, but grade into scattered Tamarack (*Larix laricina*) and stunted Black Spruce where the water table is particularly high. With the exception of regeneration from a 1928 burn, most of the region was covered by mature forest during the period of this study.

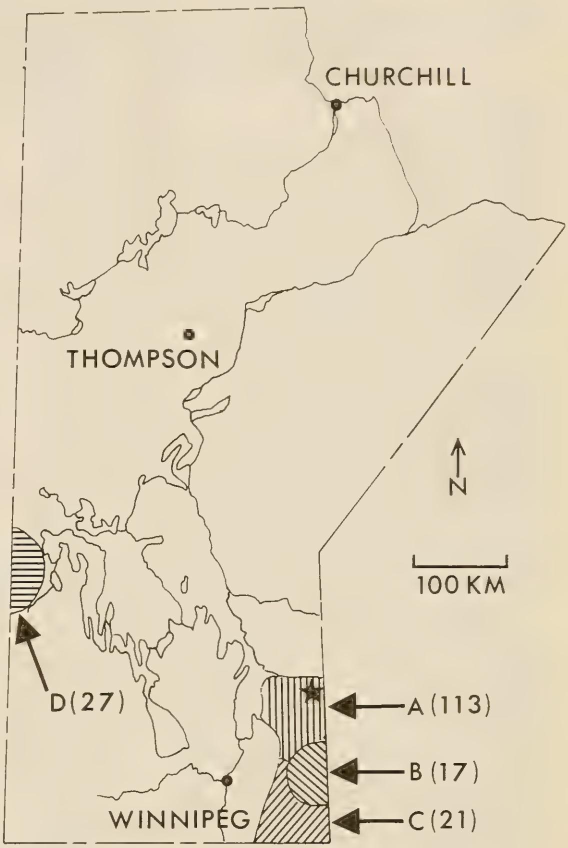

FIGURE 1. Location of extensive study areas, approximate location of intensive study area (denoted by star), and the geographical distribution of Fisher carcasses collected from known areas. Sample sizes are in parentheses. A — East Lake Winnipeg, B — Whiteshell, C — Southeast, D — West.

Methods

Laboratory Techniques

A total of 195 Fisher carcasses was collected from trappers in the extensive study area from 1972–73 to 1977–78 (Figure 1; Table 1). Staff of the Department of Natural Resources, Government of Manitoba, obtained carcasses from the Whiteshell, Southeast and West regions. I collected most of the carcasses from the East Lake Winnipeg area. Most specimens were placed in plastic bags and a label including date of capture, location, and sometimes type of set and/or bait was attached. Prior to collection, carcasses were exposed to a wide variety of weather conditions; some were thawed and refrozen several times and others were frozen quickly at low temperatures. I was able to

TABLE 1. Distribution of trapper-caught Fisher specimens in Manitoba by year and month.

Winter	November	December	January	February	March	Unknown	Total
1972-73			1	1		10	12
1973-74		1	1	1	3	7	13
1974-75	7	12	6		2	15	42
1975-76	12	7	6	13	3	11	52
1976-77	17	15	11	8	3	7	61
1977-78	2	2	1	5			10
Unknown						5	5
Total	38	37	26	28	11	55	195

examine five specimens that were previously unfrozen.

Each carcass was thawed at room temperature, examined for anomalies and missing parts, and assigned a catalogue number that followed the specimen through all processing steps. Individual specimens were weighed, measured (L., T., H.F.) and eviscerated. Lungs, heart, liver, kidneys, mesentaries, and body cavity of most carcasses were examined for presence of helminths (Dick and Leonard 1979). Female reproductive tracts were removed and trimmed of excess fat and connective tissue. After volumes were recorded, tracts were preserved in 10% formalin or Bouin's fixative. The tunica vaginalis was stripped free and the combined volumes of testes and epididymides were recorded. If only a testis and epididymis were present, their combined volume was doubled to maintain comparability. Testes and epididymides from Fisher, taken in January, February, and March were stored in Bouin's fixative.

Each eviscerated carcass was stripped of excess fat and muscle. The skull, baculum, innominate bones, scapulum, and one set of fore and hind long bones were boiled in water for approximately 20 minutes. All loose teeth (usually all canines, incisors, and some premolars and molars) were extracted and stored in labeled vials of 70% ethanol. The remaining material was processed in an enzyme bath, washed, air dried, and stored in plastic bags.

The criteria of Wright and Coulter (1967) were used to segregate specimens into four classes: adult male, adult female, juvenile male, and juvenile female. Juveniles were all less than one year of age. Teeth were shipped to C. Douglas and M. Strickland[1] for sectioning analysis and age determination because of their expertise with Fishers. Lower teeth (canines, and if necessary, first and second premolars) were decalcified in 5 per cent nitric acid and the root portions were embedded in paraffin. Roots were sectioned longitudinally at 10 microns. Sections were stained with hematoxylin (8-15 min) and eosin (2 min) and were examined under a light microscope at 40 and 100 power. Strickland and Douglas identified and counted annuli for each submitted specimen. I repeated the counts using their methods (Strickland and Douglas, unpublished manuscript). Female reproductive tracts were examined for gross signs of physiological activity. Ovaries were cut from the tract, dissected from the bursa, washed in 90 per cent ethanol, lightly blotted, and were slightly air dried. Each ovary to be sectioned was glued (Permabond, Lepage's Limited, Bramalea, Ontario) to a glass slide that was fastened by a metal block to the chuck of an Oxford vibratome (Model G, Catalogue #501, 502). Slow vibratome speed and high amplitude were used to section ovaries at thicknesses varying from 10 to 175 microns. Sections were placed in order on a glass slide and examined under a dissecting microscope (20 and 40 power). Follicles and corpora lutea were examined, counted, and usually measured.

Testes were removed from fixative and a portion of epididymis was excised, smeared on a glass slide, air dried, and examined under a light microscope (150 power) for presence of mature sperm (after Flook 1970). Bacula removed from the enzyme bath were air dried and weighed to the nearest 0.01 g.

Field Techniques

Fishers were trapped in the intensive study area with standard wire-mesh box-traps baited with carrion and/or scent. Fentanyl citrate-droperidol (Innovar-Vet)[2] mixed with atropine sulphate[3] was administered intramuscularly to immobilize all captured Fishers. Fishers were usually handled and drugged twice: once for general examination, eartagging, age determination, and measurements; and once for fitting a radio collar. The sex of live Fishers

[1]Ministry of Natural Resources, 7 Bay Street, Parry Sound, Ontario, P2A 1S4

[2]Pitman-Moore Ltd., Scarborough, Ontario.

[3]Moore Kirk Laboratoires Inc., Worcester, Massachusetts, 01600.

was determined and they were placed in juvenile or adult age classes (Wright and Coulter 1967). Presence or absence of a palpable sagittal crest, body size, and condition of teeth were used as criteria in age determination of eight Fishers including four dead, unskinned specimens. Ages of five of these Fishers were later determined using dental, skull, and skeletal criteria. All were placed in the correct age class when first examined in an unskinned condition.

Fishers captured in the field were examined for reproductive condition. Testes were palpated and measured with a plastic rule. The criteria of Enders and Leekley (1941) were used to determine the presence of estrus in females.

An AVM model LA12 portable receiver (AVM Instrument Co., Champaign, Illinois) and a four-element yagi antenna were used to locate AVM model SB-2 transmitters powered by individual lithium batteries. The transmitter, battery, and brass antenna were encapsulated with dental acrylic (Mech et al. 1965). Transmitter packages emitted a discontinuous signal from 150.850 mHz to 151.50 mHz. A typical package weighed between 80 and 120 g, and was less than 4 per cent of the total body weight of the Fisher to which it was attached.

Standard triangulation techniques (Brander and Cochran 1969) were used to locate transmitters. If possible, more than two azimuths were obtained to verify a location. Attempts to use fluctuations in signal strength to determine activity were generally unsuccessful because transmitters sometimes produced an erratic signal even when stationary.

The movements and behavior of Fishers during the mating period were studied. The mating period is defined as the period when males are capable, due to production of mature sperm, of impregnating a receptive female and when females are becoming reproductively active as evidenced by swelling of reproductive tracts. Onset of the mating period was determined from gross changes in reproductive tracts of carcasses from males and females in the East Lake Winnipeg area. Although not all females are receptive at the same time, the period appeared to begin in early March in the intensive study area. One adult female was radio-tracked during the mating period in 1976 and 1977. One juvenile female and one adult male were radio-tracked during the mating period in 1977.

Individual radio-tagged and untagged Fishers were tracked a total of 17.7 km in March 1976 and March 1977 when suitable snow cover was present. Information on track size and gait length was used to record the sex of some individuals. The methods were verified in March 1977, when radio-collared individuals of each sex were present in the intensive study area. When a track was located or a trail was followed, information related to reproduction was recorded. This included scent markings and distance from, and behavior toward, other Fisher tracks.

Results

Age of Sexual Maturity and Timing of Reproduction

Eighty-one juvenile females collected during November, December, January and early February had reproductive tracts that showed no gross signs of increased physiological activity. All had tracts with a volume less than 0.7 ml. All 41 pairs of ovaries that were sectioned had relatively small developing follicles less than 0.1 mm in diameter. Two juvenile females killed on 1 and 8 March had large Graafian follicles up to 0.6 mm in diameter and each tract was engorged to a volume of 2 ml. A post-estrous tract from a juvenile female collected in late March had increased in volume to 4 ml. The right ovary contained two recently-formed corpora lutea and the left ovary had two Graafian follicles; each of the latter displayed an oocyst on an antrum. The presence of corpora lutea in the ovaries of yearling females (one cementum annulus) indicated that ovulation occurred when these females were in the juvenile age class.

Estimated dates of parturition, based on development of embryos from three adult females in active pregnancy, were late March and early April. Periods of estrus of these females were estimated to occur in early April. The adult female live-trapped in the intensive study area whelped a litter in captivity on 28 March 1976. Between 3 and 5 April 1976 at least one male approached within 25 m of her cage. On 8 April 1976, one day prior to release, her vulvular region displayed external signs of estrus. She whelped a litter in the wild in early April 1977. The presence of corpora lutea in her ovaries in December 1977 indicated that she again underwent a period of estrus after her April parturition date.

Figure 2 shows the maturation of testes of a combined sample of juveniles and adults taken during winter. Only juvenile (n = 3) and adult males (n = 3) taken in March were spermatic. Figure 3 compares juvenile and adult bacula weights. The wide range of adult bacula weights is probably due to the presence of several adult age classes; however, small samples preclude further segregation.

Termination of breeding activity, the length of time a female would remain in estrus if not impregnated, and dates of recrudescence of testes were unknown because of the paucity of observations and specimens after early April. Juveniles collected in November and December exhibited markedly uniform degrees of suture closure and skull and skeletal development, implying that termination of reproductive activity may closely follow the observed onset in late March and early April and that timing of parturition is similar for all age classes.

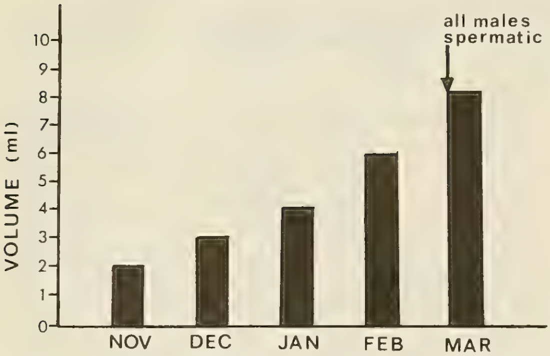

FIGURE 2. Maturation of testes of juvenile and adult Fishers during winter (n = 31).

Description of Reproductive Activity

Fisher activity in late winter increased over mid and early winter periods. Although much of the increase was associated with the presence of a snow cover more favorable for locomotion, particularly in February of both winters (Leonard 1980), changes in behavior of some Fishers were related to reproductive activity.

Much of the activity during March appeared to be due to movements of males; 14 of 18 tracks that could be assigned to sex were made by males. This proportion differed significantly from a 50:50 distribution ($\chi^2 = 11.8$, d.f. = 1, $p < 0.005$). In March 1977 a radio-tagged adult male and at least one other male of unknown age moved into the immediate area occupied by the radio-tagged female in active pregnancy. Earlier in winter, males had not been known to frequent the general area. Tracking evidence indicated that males did not approach closer than 0.5 km from the adult female in her resting den. Both sexes were apparently aware of the opposite sex in the area, investigated other Fisher tracks, and frequently marked elevated surfaces such as rocks and stumps with combinations of urine, musk, and scats. The adult female investigated the site where the male was live-trapped and approached within 150 m of the Taiga Biological Station where the male was being radio-tagged. Four days after I initially detected the adult male in the area, it moved out of radio reception in less than 8 h.

Although tracks of different males were observed less than 1 km apart, no male-male interactions were recorded. Skulls from carcasses of males frequently exhibited fractured zygomas, an injury that was never observed in females. This type of injury was significantly more common in males that had experienced at least one mating season (adults) than in males too young to have passed a mating season (juveniles) ($\chi^2 = 13.5$, d.f. = 1, $p < 0.005$). However, one of five

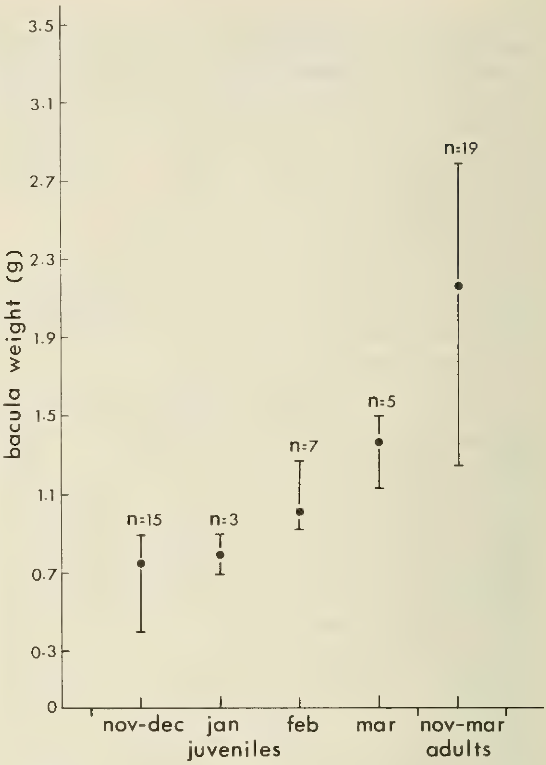

FIGURE 3. Comparison of juvenile and adult bacula weights of Fishers during winter. Vertical bar denotes range. Dot denotes mean.

juvenile males collected in March, during the onset of the mating period, had a recently-fractured zygoma.

Data on movements of a juvenile and an adult female during the breeding period were obtained by radio-tracking. Figure 4a and 4b show the movements of the adult female during two known periods of estrus in April 1976 and April 1977. Figure 4c shows that the juvenile female extended her movements and travelled out of radio-reception during the mating period.

Fertility and Productivity

Thirteen of 16 (81%) adult females were pregnant during winter. Mean and mode corpora lutea (CL) counts for pregnant females were 3.5 and 3, respectively. The mean number of CL per female was reduced to 2.8 when barren females were included in the sample. Figure 5 shows the regression of mean CL/female (including barren females) on age. Three adults in active pregnancy each had three embryos. For these females a total of 10 CL was recorded, indicating an *in utero* loss of 10 per cent. A three-year

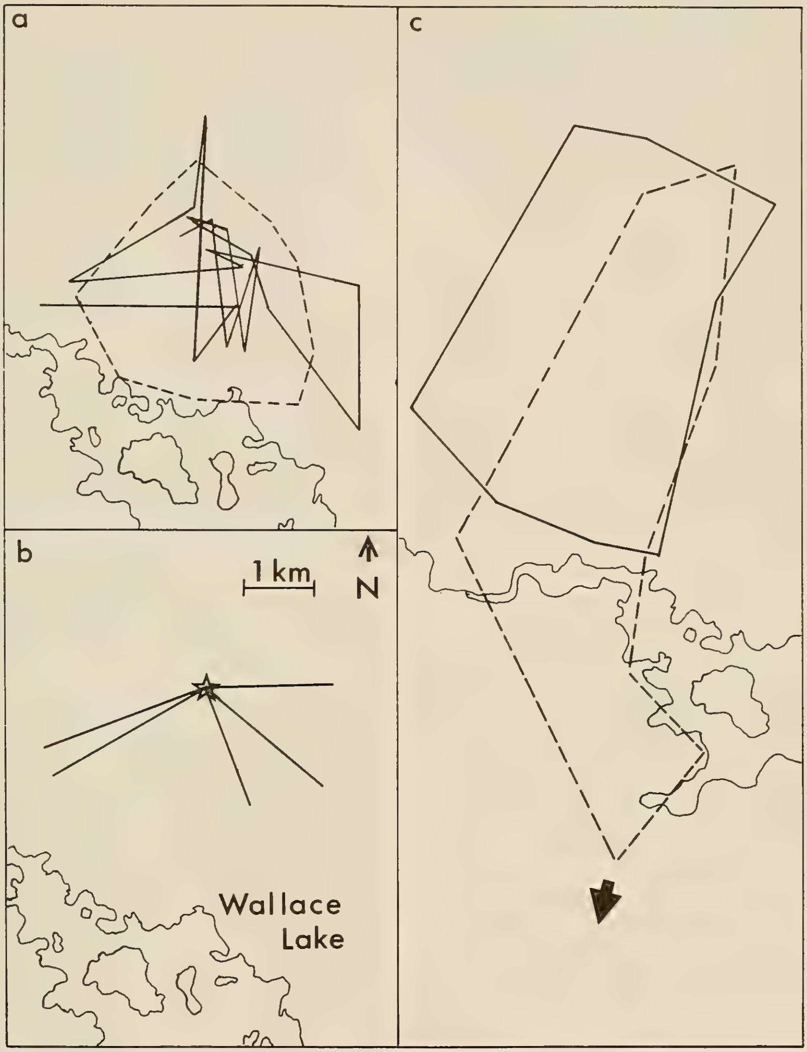

FIGURE 4. Movements of female Fishers determined from radio-telemetry during the mating period (see text for definition).

a) Extensive movements of a barren adult female in estrus in April 1976 (n = 71; solid line) in comparison to a polygon containing 95% of radio-relocations during a subsequent four month period (n = 247; dashed line).

b) Movements of the same adult female during a period of estrus in April, 1977. Location of kits resulting from estrus described in (a) and the den are denoted by a star. Solid lines show direction and maximum distance travelled from the den. Return routes were along the same general line of travel. Corpora lutea in this female's ovaries in December 1977 indicate that she successfully copulated with one or more males during this period.

c) Change in movements of a juvenile female during the mating period. Solid line depicts area used by the female from 22 February to 14 March, 1977 (n = 31). Dashed line shows expansion of range which occurred between 15 March and 29 March, 1977 (n = 68). Arrow shows the direction of travel of the female when radio-reception was lost.

TABLE 2. Productivity and fertility indices from Fishers collected in Manitoba during winter.

	Productivity				Fertility	
Winter	Number of juveniles	Number of adult females	Minimum number of post parturient adult females[1]	Juveniles: post parturient adult females	Number of pregnant adults	Mean number corpora lutea/pregnant adult
1972-73	8	2	1	8:1		
1973-74	10	1	1	10:1		
1974-75	28	7	6	5:1	3 of 4	3.7
1975-76	44	4	3	15:1	3 of 4	2.7
1976-77	48	6	6	8:1	6 of 6	3.5
1977-78	8	1	1	8:1	1 of 1	4.0

[1]Adult females possessing two cementum annuli (estimated to be 2.5 years old).

history of reproduction was known from the radio-tagged adult female: she whelped four kits in March 1976, whelped at least two (observation in field) and possibly four (placental scar counts) in April 1977, and had four CL in December 1977. Little variation in indices of fertility rates and productivity existed among years (Table 2).

Physical Characteristics of Litters and Maternal Behavior

The radio-collared adult female whelped a litter of four kits in captivity in March, 1976. Three female Fisher kits weighed 30.7 g, 26.0 g, 30.0 g and a single male weighed 30.0 g. The kits apparently did not suckle and died about 36 h after parturition. Kits were extremely altricial with no body hair except for a faint, light grey mane along the mid-dorsal area. The eyes were closed. When the female was present in the next box the kits vocalized weakly with a type of mewing similar to that of young domestic kittens. The female remained motionless in the nest box with the kits when approached closely by humans. This was contrary to the active response that the female exhibited when approached prior to parturition and after death of the kits.

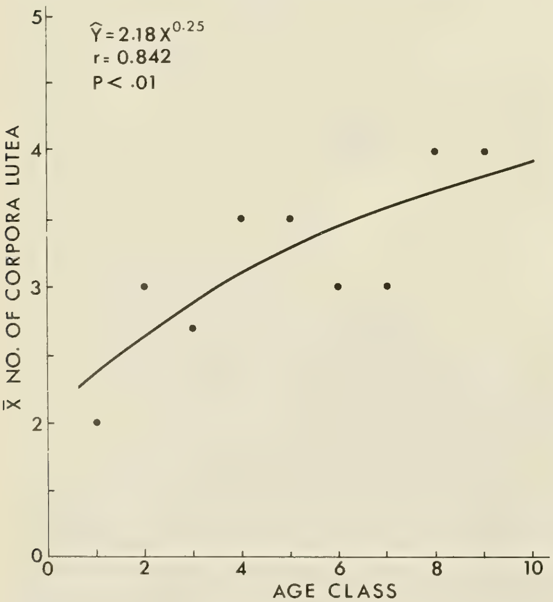

FIGURE 5. Regression of mean number of corpora lutea per adult female on age class.

The same female whelped kits in a hollow Trembling Aspen (*Populus tremuloides*) tree in early April 1977. I observed the kits and female on two occasions and saw the female in the den and heard the kits on another. I also visited the den site when the female was hunting, but did not observe the kits. Behavior was similar to the situation the prior year in captivity. When the female was present, kits mewed loudly and could be heard on a calm day at a distance of 20 m. However, kits were quiet whenever the female left the den.

I observed the female and kits through a 40X spotting scope on 19 and 22 April when the kits were about 21 days old. Using the relative size of the kits born the previous year as a comparison, it was evident that growth in the first three weeks had been rapid, but this could not be quantified. The hair of the wild-born kits had changed to a medium shade of brown and had a broader distribution on the body compared with that of the captive new-born kits. At 21 days kits remained extremely altricial with eyes closed. They were capable of raising portions of their body but could not crawl or climb.

Observations of the female and kits were discontinued because the female was always aware of human presence, no matter how carefully approached or concealed, and when disturbed she did not leave the den to hunt until the following day.

Discussion

Reproductive Characteristics

Eadie and Hamilton (1958) inferred, from examination of skeletal and reproductive characteristics of 39 female Fishers from New York, that individuals displaying specific open skull sutures and absence of corpora lutea were members of a non-breeding, winter age-class. Wright and Coulter (1967) confirmed these observations in a study of development and reproduction of 99 females from Maine. They also presented, by finding tubal morulae in two Fishers with juvenile skull characteristics, the first irrefutable evidence that wild female Fishers breed at the age of one year. Studies of age-class structure and reproduction of Fishers from Ontario (Strickland and Douglas 1974, 1979, 1981) also supported these earlier observations. In Manitoba, presence of pregnant females in the yearling age class, increased tract volume and follicular development of two pre-estrous juvenile females, and observation of a tract from a recently-bred juvenile indicate that first reproduction of females also occurs at the end of the first year of age.

Age of first reproduction of male Fishers is poorly understood because a thorough study of a large series of testes has not been undertaken. To complicate matters, even if reproductive capability of juvenile males is demonstrated in the laboratory, there presently is no effective method of determining reproductive success of males in the wild. Wright and Coulter (1967) found sperm in epididymides of five adult males and two juvenile males collected during March in Maine. Although I used a method not strictly comparable, I found sperm in the epididymides of three juveniles and three adults from March, but I could not detect sperm from a larger series of juveniles and adults collected from November to February. The similarity in trend of monthly testes volumes of juveniles and adults implied that winter maturation of gonads followed a similar pattern for both age-classes. These data are supported by the overlap in weights of bacula of adults and juveniles collected during late winter in Maine (Wright and Coulter 1967) and Manitoba (Figure 3). Sexual maturation of males during winter appeared to differ in Ontario. In their southern Ontario study area Strickland and Douglas (1981) recorded almost no overlap in weights of bacula of juveniles and adults collected from November to March. Earlier they reported a mean monthly testes weight of juveniles that was consistently lower than that of adults (Strickland and Douglas 1979). When a shortage of adult males was apparent in this population, the juvenile males appeared incapable of breeding because numerous barren females were recorded the following year (Strickland and Douglas 1981). Management that favored protection of adults eliminated this phenomenon (Strickland and Douglas 1981). It appears that age of sexual maturity of males is probably more variable than in females. Perhaps age of first reproduction in males varies geographically, or, as Crowe (1975) believed for Bobcats (*Lynx rufus*), may be more closely related to physical development than age.

In Manitoba, all available information indicates that estrus and parturition occur in late March and April. The fact that early winter juveniles were very uniform in development suggests that a restricted whelping period and possibly a restricted mating period occur for all ages of reproducing females. The rigors of climate in Manitoba probably preclude successful whelping and raising of kits earlier than late March. Studies from areas with a less harsh climate, such as Maine (Wright and Coulter 1967) and southern Ontario (Strickland and Douglas 1974), have reported females in active pregnancy during nearly all winter months. Fishers from regions with less severe environmental conditions in late winter should not only show a wide spread of parturition dates, but the juvenile age-class should display more early winter developmental variation than Manitoba juveniles. However, variation in development of juveniles has not been examined in these regions.

No data are available on aspects of the reproductive cycle of male and female Fishers between April and October in any portion of their geographic range. Danilov and Tumanov (1972) showed that some male mustelids, including Forest Marten (*Martes martes*), remain in breeding condition for two to four months regardless of the annual timing of breeding of a respective species. If recrudescence of testes in the Fisher requires about the same amount of time as development (Figure 2), then it may be inferred that male Fishers are sexually potent during March, April, and May in Manitoba. Few meaningful inferences may be made on reproduction of female Fishers from April to October.

There appears to be little geographic variation in mean corpora lutea counts for fertile females. The mean of 3.5 corpora lutea for Manitoba is similar to 3.3 (n = 47) for Ontario (Strickland and Douglas 1979), 3.3 (n = 19) for Nova Scotia (van Nostrand 1979), 3.28 (n = 44) for Maine (Wright and Coulter 1967), 3.67 (n = 12) for New Hampshire (Kelly 1977), but is greater than the 2.72 (n = 22) for New York (Eadie and Hamilton 1958) and the 2.6 (n = 5) for Massachusetts (Cardoza 1979).

Counts of embryos probably more accurately reflect the true litter size, but data are rare due to limited availability of late-winter carcasses. Wright and Coulter (1967) recorded a one:one ratio between corpora lutea and embryos for each of eight females in

active pregnancy. The 10 per cent *in utero* loss that I recorded was similar to the 6 per cent discrepancy between corpora lutea and blastocysts from 11 serially sectioned tracts from Maine (Wright and Coulter 1967). Although sample sizes are not comparable, the mean embryo count was lower in Manitoba $\bar{x} = 3$; n = 3) than in Maine ($\bar{x} = 3.45$; n = 11; Wright and Coulter 1967), and Ontario ($\bar{x} = 3.16$; n = 16; Strickland and Douglas 1974).

Data on size of wild litters are non-existent, but records from captive litters indicate that a further decrease in fertility rate may occur before parturition. Hall (1942) reported that the mean number of young for 26 fur ranch Fishers was 2.7. Other litters include two of three young each from Maine (Coulter 1966), one of two young from Michigan (Powell 1977), one of three young from Vermont (Fuller 1979), and the litter of four young I reported from Manitoba. Unfortunately, there are no data available concerning neonatal mortality in the wild.

The regression of mean corpora lutea per female on age (Figure 5) indicates that age-related fertility rates may exist in Manitoba. Although similar data from other regions have not been analyzed, information tabled by Strickland and Douglas (1979) appears to follow a similar age-specific trend. Data supporting age-related productivity are in contradiction with the evidence I presented for constancy in litter size in a single adult female. Kelly's (1977) report of a road-killed female that had three placental scars and three blastocysts also supports constancy of litter size for an individual. Change in fertility with age is more probable than constancy in fertility but more detailed analysis of larger samples is required.

Population density may be an important factor in determining the ratio of fertilized to unfertilized females. Areas with dense Fisher populations, such as New York (Eadie and Hamilton 1958) and Maine (Wright and Coulter 1967), have not reported barren females. Presence of barren females in a relatively dense population in southern Ontario was attributed to a shortage of adult males (Strickland and Douglas 1981). In Manitoba, indices of population density, such as sustainable trapper-catch (Manitoba Game Branch Records), indicate the existence of a lower population density than many other areas. A total of about 19 per cent of the adult females was barren, a figure that compares closely with the number of barren females in a low density population in Nova Scotia (van Nostrand 1979). The reason why most barren females in Manitoba were young individuals is not clear.

The ratio between the number of juveniles in the sample and the number of females old enough to have produced these juveniles (Table 2) shows that there was no noticeable change in productivity from 1972 to 1978. Fertility rates of females from 1974-75 to 1977-78, although based on smaller samples, also support inferences from age-ratio comparisons. It appears that despite the presence of a fluctuating prey base and a ten year cycle in fur returns of Fisher in Manitoba (Manitoba Game Branch Records), there is little evidence to suggest that population dynamics of Fishers is affected in the manner reported for Lynx (*Lynx canadensis*) (Nellis et al. 1972; Brand et al. 1976; Brand and Keith 1979). However, in Ontario Strickland and Douglas (1981) did report a seven-fold variation in the ratio of juveniles per adult female older than two years but the cause was attributed to a paucity of breeding males.

Observations on the maternal behavior of the same female in captivity and in the wild are of value because this situation allows a direct comparison of two circumstances without the confounding variable of two individual adult females being introduced. In both cases the female demonstrated a tendency to conceal herself and her litters when approached closely. This may be one reason why anecdotal reports of females and litters have only been recorded in the wild a few times (Seton 1909; Hamilton and Cook 1955) and why the observation I present of the wild litter may be the first described. This ability to conceal litters and the fact that kits are silent when unattended by the maternal female are likely adaptations to reduce the probability of detection and predation by other species, or destruction of litters by adult males, a feature reported in other carnivores.

The weights and description of new-born Fisher kits in Manitoba can be compared to much more complete data from captive litters in Maine (Coulter 1966) and Michigan (Powell 1982). The weights I presented were about 10 g less than weights Coulter (1966) showed for a pair of three day old kits that died in captivity. Weights of individuals of both these litters support the hypothesis that there is no sexual dimorphism in weight at birth in Fishers. The age at which the sexual dimorphism exhibited becomes apparent is not clear from Coulter's (1966) findings, but Powell (1982) reported that a male was heavier than his female sibling when first weighed at 18 days. Developmental characteristics of new-born kits I reported were similar to observations of Coulter (1966) and Powell (1982).

The capability of movement and pelage characteristics I described for 21 day old wild kits were similar to those reported by Coulter (1966) for his captive litter. However, Powell (1982) reported that his kits were more mobile at 21 days than were the kits Coulter (1966) observed. In addition, the kits Powell (1982) raised grew heavier and opened their eyes earlier than

did Coulter's (1966) kits. The fact that Powell (1982) removed the kits from the attending female and fed them an *ad libitum* diet of high quality foods may have been the reason for the more rapid growth and development. It appears that wild kits may more closely reflect the development of a captive litter that is attended by the adult female, rather than the more artificial situation of being hand-raised by humans. Of course, any definitive comparison of growth rates and development of wild and captive litters would have to be substantiated by weights and measurements taken in time. The sensitivity to human disturbance that I reported for the wild-ranging female will no doubt preclude the collection of these data from wild litters in any future study. Therefore, if data on growth and development of Fishers are needed for comparative studies, care must be taken to select data from captive groups which reflect the wild situation most closely.

Several conclusions can be drawn from the study of reproductive characteristics of a northern Fisher population from Manitoba: (a) age of first reproduction of males and females is similar to other regions; (b) parturition and consequently estrus occur during a more limited time period than in other regions; (c) fertility rates of pregnant females are similar to those of other regions; (d) barren females are present and serve to lower productivity, but this may be related to population density; (e) age-related fertility rates appear to exist; and (f) managers of fur harvests can apply some techniques applicable to eastern populations if future data show that age-specific mortality rates do not differ greatly between northern and eastern regions.

The Breeding System

Coulter (1966) provided the only source of information on changes of Fisher activity during the breeding season. In his intensive study units in Maine he found that Fishers followed other Fisher tracks, made trails, and used scent posts more frequently than earlier in winter. My observations from Manitoba basically agree with Coulter's (1966) work, but because of radio-telemetry data on animals of known sex and age I am able to further the development of a hypothesis on the breeding system of the Fisher and present supporting evidence.

The adult female was relatively sedentary and remained within her established home range during two estrous periods which both differed, in a behavioral sense, due to her parental status (Figure 4a,b). This suggests that adult females are closely tied to a core area and, even if barren, do not range widely during estrus in a fashion demonstrated by the radio-tagged juvenile female (Figure 4c). Although there are no other data available on activities of females during estrus, an adult female in New Hampshire also used a small range in which she was captured twice during lactation (Kelly 1977).

Males must first locate females in order to copulate with them. Many of these females are adults which are presumed to occupy relatively restricted ranges. Because female Fishers do not synchronously enter estrus and are not particularly dense due to the form of social organization usually attributed to a solitary carnivore (Powell 1979b), the resource for which males search, namely, a female in estrus, is no doubt limited both spatially and temporally. If males defend a range against other males, as has been shown for other mustelids and suggested for the Fisher (Powell 1979b), they may maximize their fitness in two ways: (1) continue to defend ranges against other males and mate with as many resident females as possible, or (2) allow intrasexual spacing mechanisms to break down and travel more widely in an effort to mate with additional females, but suffer the genetic expense of allowing other males to copulate with females within the original defended area. The following evidence points to the second strategy as being more plausible and perhaps ecologically more practical than the first.

The general increase in male track observations in the intensive study area, particularly in locations where numbers of males did not exist in early winter, suggests that during the onset of the mating season males moved more extensively than earlier in winter. The movement of males into the immediate vicinity of the adult female and the rapid long-range departure of the radio-tagged male support track observations and also imply that intrasexual spacing mechanisms of males had broken down. The increased track activity reported by Coulter (1966) may have been a close duplicate of the relationships I observed in Manitoba. He reported that much of the increased activity occurred in a three square mile area, a size that may typically represent the area occupied by a single adult female in or approaching estrus. If these observations are not a result of small samples or observer error, then it appears that Fishers have a breeding system in which non-breeding period territoriality breaks down and males actively search out females in estrus. The evidence presented is further strengthened by the fact that similar systems have been recorded for other solitary mustelids such as Weasels, *Mustela nivalis* (Erhlinge 1974; King 1975) and Stoats, *Mustela erminea* (Erhlinge 1977).

Functioning of such a breeding system would demand that males will eventually confront one another and some form of behavioral interaction should result. The fact that I did not record male-male interaction in the field does not necessarily conflict with the proposed system because the adult female that was attracting the males was not yet in estrus, a

condition that may be the most important, or perhaps the only factor that could release a male fighting response. The circumstantial evidence of skull injuries present in breeding-age males certainly tempts one to propose a system involving a great deal of male interaction. The extreme sexual dimorphism of Fishers (Coulter 1966; Powell 1977; Kelly 1977) is probably a result of pressures of sexual selection and is a very good indicator of the degree of male interaction in the breeding system, although Powell and Leonard (1983) did demonstrate that small female size could be due to energy constraints when kits are raised.

A breeding system in which adult males actively search for mates and allow territorial defense to break down appears to be maladaptive, but a number of factors must be considered. Juvenile males are fertile and many are probably transients during their first winter (Leonard 1980). If adult males are to defend a fairly large area covering several adult female ranges, then they must expend considerable amounts of energy in an effort to prevent transient males from breeding with resident females. However, it may not be physically feasible for adult males to prevent juvenile males from copulating with resident females because olfactory spacing mechanisms, such as scent posts, may be less effective during the breeding period. In addition, adult females are probably not closely spaced and juvenile females, also in estrus at this time, are capable of ranging widely (Figure 4c). Energy required by males for defense of an area may therefore be more economically used for searching for receptive females in regions within and beyond the non-breeding defended area.

The degree of promiscuity of female mustelids is a feature of reproduction that is poorly known. It is generally believed that female mustelids are induced ovulators requiring stimulus of copulation (Ewer 1973). Fishers are known to copulate for extended time periods of up to several hours (Hodgson 1937; Laberee 1941). My record of corpora lutea and Graafian follicles in different ovaries of a single female indicates that females sometimes require more than one of these copulation periods for release of the usual number of ova. Given the field evidence and injuries to male skulls that could have been caused by male-male interaction, the probability of a promiscuous breeding system in which males compete for copulations is further substantiated. Additional evidence includes the fact the Strickland and Douglas (1981) noted that a form of non-trapping mortality affected only males and could be attributed to intra-sexual fighting as evidenced by bite marks on pelts of males. Assuming no female selection for mates, as Poole (1967) showed for captive Ferrets (*Mustela putorius*), this system would also imply that litters of mixed male parentage are likely in Fishers. However, since the radio-tagged adult female approached areas where the adult male was captured and later where it was held captive, it remains possible that females exert influence in choice of mates.

With the availability of only limited field data, caution is advised when hypothesizing about a breeding system that is the result of a long evolutionary history. As Ralls (1977) correctly emphasized, contribution of genes in the successive generations is the most important parameter to be measured when addressing the related problems of sexual selection and mating systems. Sexual selection and male dominance may sometimes be poorly correlated with actual genetic contribution to future generations. For example, Duvall et al. (1976) showed, through a study of blood types, that a dominant male in a hierarchical primate social unit could have sired no more than 30% of the current young of the group. A considerable amount of field data will be required, preferably from marked individuals, to test adequately speculations on the breeding system of the Fisher that I have proposed.

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Rorippa truncata, the Blunt-fruited Yellow Cress, New for Canada, and *R. tenerrima,* the Slender Yellow Cress, in Southern Saskatchewan and Alberta

VERNON L. HARMS[1], JOHN H. HUDSON[1], and GEORGE F. LEDINGHAM[2]

[1]The W. P. Fraser Herbarium, University of Saskatchewan, Saskatoon, Saskatchewan S7N 0W0
[2]Herbarium, University of Regina, Regina, Saskatchewan S4S 0A2

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Rorippa truncata (Jepson) Stuckey is reported from eight southern Saskatchewan localities and one southern Alberta locality. These records are the first of the species for these provinces and for Canada. Another annual yellow cress species, *R. tenerrima* Greene, is reported from three sites near Rockglen, southern Saskatchewan, as new for the recorded flora of the province.

Key Words: *Rorippa truncata, R. tenerrima,* Yellow Cress, Saskatchewan, Alberta.

For some time, Saskatchewan botanists have been aware of the occurrence in the province of at least one annual *Rorippa* taxon of small, prostrate to more or less decumbent plants, much branched from the base, with leaves glabrous, the flowers short-petalled, and the siliques more or less cylindrical, short-pedicelled, and with readily dehiscent valves and glabrous replum margins. As long as 30 years ago, some such plants had been identified as *R. obtusa* (Nutt.) Britt. by G.F.L., and, within the last decade, other collections have been determined as either *R. obtusa* or *R. tenerrima* Greene by us and others, although they were never formally reported for Saskatchewan under either name.

Using available keys and descriptions in most Canadian and North American national and regional flora-manuals, these largely published prior to Stuckey's (1972) revision of North American *Rorippa,* the Saskatchewan plants all appeared referrable to *R. tenerrima* (or *R. obtusa*). But when Stuckey's revised taxonomic treatment was used, most of these Saskatchewan specimens were better keyed out to *R. truncata,* based on their (1) short-cylindrical silique-fruits that are glabrous or only somewhat hyaline-ridged rather than roughened by minute papillae, mostly constricted near mid-length, and, if mature and completely filled-out, non-tapered to an obtuse apex to which the style is rather abruptly merged, rather than more gradually narrowed to a pointed summit that tapers into the style; (2) styles more linear than conical; (3) stigmas in fruit stage mostly distinctly expanded and disk-like; and (4) leaves mostly more regularly pinnatifid than lyrate, with the lobe-segments ± angular-toothed rather than entire-margined. (See Table 1 for the diagnostic characteristics judged most useful, and Figure 1 for plant habit and some of these attributes.)

Those Saskatchewan collections in SASK, USAS, ALTA and JHH*, now determined by us as best referred to *R. truncata,* are from the following localities: (1) McDonald Hills, east of Strasbourg and north of Dysart (15 July 1949, *R. C. Russell S-3948,* SASK); (2) Viscount (15 September 1951, *G. F. Ledingham 1224,* SASK, USAS and ALTA); (3) Swift Current (4 August 1964, *J. B. Millar G25,* SASK); (4) Burstall, southwest of Leader (5 September 1981, *J. H. Hudson 4200,* SASK and USAS); (5) Loreburn, north of Elbow (11 September 1982, *J. H. Hudson 4324,* SASK and USAS); (6) Mortlach (12 July 1950, *J. H. Hudson 356,* JHH); and (7) Parkbeg (20 July 1950, *J. H. Hudson 415,* JHH). Despite its rather more tapering conical silique summits, the following collection was also determined as at least nearest to *R. truncata:* (8) Pinkham, southwest of Kindersley (11 July 1982, *J. H. Hudson 4223,* SASK and USAS). In addition to the foregoing Saskatchewan localities, the following collection from southcentral Alberta has also been determined as *R. truncata:* (9) 16 km west of Skiff (south of Taber), in "dried up slough" (22 July 1976, *Andrew Klar 2305,* ALTA). (See Figure 2).

The habitat of *R. truncata* in Saskatchewan, as observed in the field and abstracted from specimen label data, appears that of non-alkaline drying mud-flats and edges of wet open non-alkaline sloughs, on either clay-till or sandy soils. The Saskatchewan speci-

*The private herbarium of John H. Hudson in Saskatoon; the other acronyms after Holmgren et al. (1981).

TABLE 1. Diagnostic criteria abstracted from Stuckey (1972) judged by us as most useful and reliable for distinguishing between *Rorippa tenerrima* and *R. truncata* on the Northern Great Plains.

	R. tenerrima (Slender Yellow Cress)	*R. truncata* (Blunt-leaved Yellow Cress)
LEAVES: length	2–5 (–8) cm	5–12 (–26) cm
lobing form	lyrately pinnate-divided (or only lobed)	regularly pinnate-divided
lobe margins	entire or scarcely toothed	± angular-toothed
SILIQUES: apex	tapering (conical)	obtuse or truncate
surfaces	rough, with minute papillae	smooth, lacking papillae
mid-constriction	absent	usually present
STYLE (at fruit-stage): thickness	0.2–0.4 mm	0.1–0.2 mm
shape	tapered to thicker base (= conical)	straight and slender throughout (= linear)
attachment to silique body	± gradually merging	± abruptly attached
STIGMA shape (at fruit-stage)	not expanded	usually expanded and disk-like, or not

mens were collected over a time-span of more than 30 years, in simultaneous flowering and fruiting stages from mid-July to mid-September, although most July collections had few mature fruits, and September ones had few remaining flowers.

Collections from three other sites, all from within a 16 km radius west of Rockglen, in southcentral Saskatchewan, were identified as *R. tenerrima,* primarily on the basis of (1) silique-fruits distinctly minute-papillose and more tapering to a conical summit; (2) styles shorter, thicker and more conical; (3) leaves more lyrate-shaped (i.e. terminal lobe relatively much larger) and with the lobe-segments entire or scarcely toothed. Those collections in SASK and USAS now determined as *R. tenerrima* are from the following localities: (1) 5 mi. southwest of Rockglen, on moist bank above stock-watering pond below natural spring and fen (4 September 1980, *G. F. Ledingham* and *G. Anweiler 6778 & 7071,* USAS and SASK; 14 September 1984, *G. F. Ledingham 8917* and *8955* USAS & SASK); (2) 1 mi. east of Quantock, in wet grassy meadow (7 August 1980, *G. F. Ledingham* and *D. Blood 6837,* USAS); and, although vegetative, on the basis of leaf characters: (3) 1 mi. east of Canopus, in wet wooded ravine (7 August 1980, *G. F. Ledingham* et al. *6890,* USAS), [See Figure 2].

Although our collections from Saskatchewan constitute only a small sample, the habitat of *R. tenerrima* here, as apparently elsewhere (Stuckey 1972), does not seem essentially different from that of *R. truncata.* Our Saskatchewan specimens were collected in simultaneous flowering and fruiting stages from early August to mid-September. The relatively large Rockglen population (*Ledingham* et al. *6778, 7071 & 8917)* of *R. tenerrima* was composed of consistently small-leaved, almost acaulescent and rosette-type plants, as judged by collections taken five seasons apart, and this growth form was retained in greenhouse pots at the University of Regina (*Ledingham 8955*).

Elsewhere in Canada, the Slender Yellow Cress, *R. tenerrima,* often under the misapplied name, *R. obtusa* (see Stuckey 1966), has been recorded from southern British Columbia (north to Kamloops), eastward to southwestern Alberta (at Crowsnest Pass and Milk River, according to Scoggan 1978, although only mapped from Del Bonita, an upper Milk River site, by Stuckey 1972 and Packer 1983). In the adjacent United States, *R. tenerrima* is known from Washington to northwestern Montana (Stuckey 1972), and from westcentral North Dakota, where it was recorded from McLean and Oliver Counties (Stuckey 1972; McGregor et al. 1977). Stevens (1950) obviously included both *R. tenerrima* and *R. truncata* collections among his reported *R. obtusa* in North Dakota. As were the North Dakota ones, the presently reported collections from the Rockglen area in southcentral Saskatchewan came from within the Missouri River drainage system. They extend the species known range about 300 km northwestward into Saskatchewan, from the recorded North Dakota stations, and help to at least partially bridge the formerly wide distributional gap apparent between the central North Dakota and southwestern Alberta-western Montana recorded ranges of this species (see Figure 2).

FIGURE 1. *Rorippa truncata*. A. Plants showing habit and general characteristics. B. Inset showing an enlarged raceme with mature fruits. (Photographs of herbarium specimen *Ledingham 1224*, collected 14 September 1951, from Viscount, Saskatchewan).

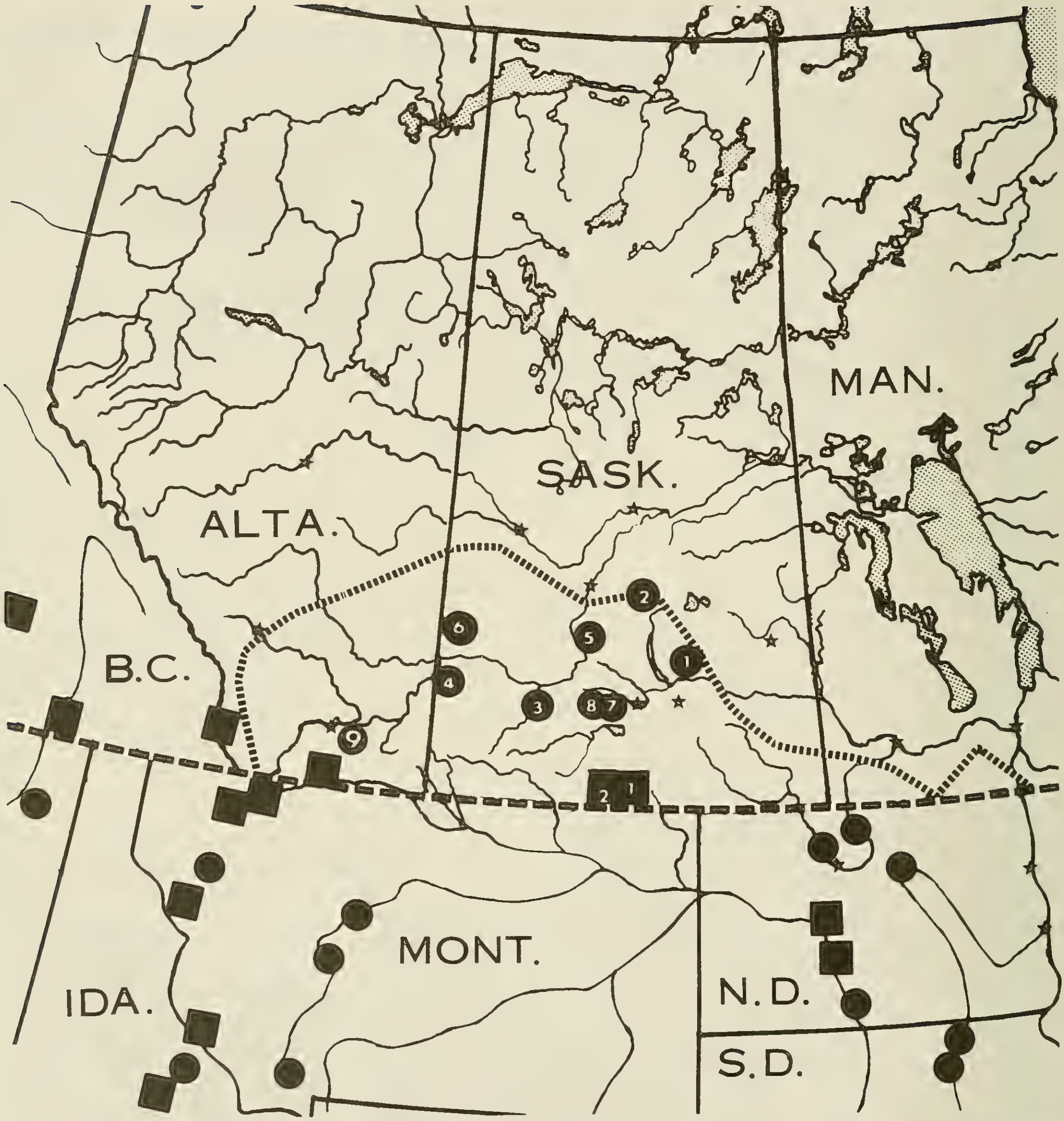

FIGURE 2. The newly reported Saskatchewan and Alberta localities for *Rorippa truncata* (= numbered circles) and *R. tenerrima* (= numbered squares), plus localities in adjacent provinces and states from previous literature reports of *R. truncata* (= solid circles) and *R. tenerrima* (= solid squares). The numbers of the Saskatchewan localities are those used in the text in reference to each. The dotted line indicates the approximate border in Canada between true grasslands and aspen parklands.

FIGURE 3. The total recorded distribution in North America of *Rorippa truncata* (= solid circles) and *R. tenerrima* (= solid squares), including the new Saskatchewan and Alberta records, plus previous literature reports from elsewhere. The non-Saskatchewan records for both species are based primarily on Stuckey (1972), McGregor et al. (1977), Scoggan (1978), and Mohlenbrock (1980).

The Blunt-fruited Yellow Cress, *Rorippa truncata,* as recognized by Stuckey (1972) and subsequent authors, is a native western North American species of moist shores, mud-flats, and other wet places. It is similar to, and not always clearly distinguished from, *R. tenerrima* Greene (*R. obtusa* auct.), *R. curvipes* Greene, *R. curvisiliqua* (Hook.) Bess., *R teres* (Michaux) Stuckey (including *R. obtusa* (Nutt.) Britt.), or even *R. palustris* (L.) Bess. *R. truncata* was a generally unrecognized taxon until segregated and defined by Stuckey (1972). Thus many standard flora-manuals (e.g., Fernald 1950; Gleason 1952; Gleason and Cronquist 1963; Hitchcock et al. 1964) preceding Stuckey's revision of *Rorippa* omitted mention of this taxon, even in synonomy, and as a result their present-day users may continue to overlook this species. But *R. truncata* has since been included for the flora of Kansas by McGregor et al. (1976), for the flora of South Dakota by van Bruggen (1976), for the Great Plains flora by McGregor et al. (1977), and for the

flora of southwestern Illinois by Mohlenbrock (1980).

No previous reports of *R. truncata* for Canada exist. In the adjacent United States, this species has been recorded from the lower Columbia River Valley along the Washington-Oregon border, from eastern Washington to western Montana (Stuckey 1972), and in northcentral North Dakota from Bottineau, McHenry and Benson Counties (Stuckey 1972; McGregor et al. 1977).

Stuckey (1972) described what he called a somewhat "odd distribution" for *R. truncata,* with the species being absent from the central Rocky Mountains, occurring sparingly in the northern Rockies from easternmost Washington to western Montana, and outward from the mountains largely confined to four major river valleys — the Columbia, the Rio Grande (n.c. New Mexico — w. Texas — Mexico), the Platte (w. Nebraska), and the Missouri (isolated stations at St. Louis, Kansas City, n.c. South Dakota and n.c. North Dakota) — plus some isolated areas along the upper Black River in eastern Arizona, and in westcentral and southcentral California. McGregor et al. (1977) better filled in the Great Plains distribution of this species, mapping it from the St. Louis and Kansas City areas, across eastern to western Nebraska, north to southeastern and northcentral South Dakota, to northcentral North Dakota. All these Great Plains records were from within the Missouri (including the Platte) River watershed except several northcentral North Dakota ones from within the Souris River watershed, the latter draining via the Assiniboine and Red rivers northwards towards Hudson Bay.

The southern Saskatchewan and Alberta stations reported here represent about a 400 km northward extension of the species' previously known range in the northern Great Plains and Foothills, and serve to at least partially bridge the formerly wide distributional gap apparent between western Montana and northcentral North Dakota (see Figure 2).

By its apparently sparse and rather scattered occurrence over a wide area of western North America, *Rorippa truncata* might phytogeographically be interpreted (in a way similar to how Stuckey (1972) explained its sister taxon, *R. tenerrima*) as a relict species more abundant in the past, which has persisted in favorable locations, especially along major rivers and their tributaries, including the Missouri River system. Of our nine Saskatchewan and Alberta records of *R. truncata,* four (McDonald Hills, Viscount, Mortlach, and Parkbeg) were from the Qu'Appelle River drainage, and five (Swift Current, Burstall, Loreburn, Pinkham, and Skiff) from the South Saskatchewan River drainage system. It is perhaps noteworthy that in early post-glacial times the relevant portions of both the South Saskatchewan and Qu'Appelle River systems were once interconnected, as was also the aforementioned Souris River, with these draining southeastward through the Missouri and Mississippi River systems.

Since both *R. truncata* and *R. tenerrima* may be somewhat weedy (i.e. invading species in more or less disturbed places), it is possible that some Saskatchewan records could represent recent invaders, especially those from such (semi-) disturbed areas as "sloughs in cultivated fields" (e.g. Viscount and Loreburn collections), or "banks of stock-watering pond" (e.g. Rockglen collections). It would seem difficult, however, to really ascertain the native versus naturalized status of such naturally "weedy" species of open, wet-to-drying-out habitats. Since most of the Saskatchewan collections have come from apparently natural habitats, we judge it more likely that both *Rorippa* species represent rare native taxa that previously were overlooked. The Saskatchewan collections are too few in number, and historical information is too meager, to judge possible effects of human activities such as slough-cultivation or cattle-grazing on the habitat-availability and population size changes of these annual yellow cress species.

While the available Saskatchewan and Alberta material hardly represents an adequate basis for taxonomic judgements, some of the diagnostic criteria used by Stuckey (1972) for the specific separation of *R. tenerrima* and *R. truncata* would appear either unclear or difficult to apply. Fruit maturity and the completeness to which the upper silique portions are filled out affect the degree to which an obtuse vs. conic apex is revealed (e.g. our Burstall, Loreburn, and Pinkham collections reveal many siliques not well filled out in their upper halves, these then appearing more tapered toward the summits and stylar attachments, although fully filled siliques on the same plants show obtuse summits more abruptly merged to the style). Saskatchewan specimens of both species show the majority of siliques to be relatively straight, but also many that are more or less curved. Interpretations of which shoots represent lateral racemes vs. main stems or branches with terminal racemes, and the relative sequences of raceme maturity, often seem difficult and equivocal in the case of such basally branched, prostrate to decumbent plants. The latter characters appear to be strongly influenced by the environmental growing conditions and seem essentially similar for both species. Although such information might be helpful for making taxonomic judgements, we have found no chromosome number reports for either species. Table 1 reflects those diagnostic characters judged by us to be most useful and reliable for separating *R. tenerrima* and *R. truncata*

on the Northern Great Plains.

The newly reported Saskatchewan and Alberta localities for *Rorippa truncata* and *R. tenerrima* are mapped in Figure 2, together with the previous literature reports for both species in immediately adjacent provinces and states. The total recorded distributions of both species in North America are mapped in Figure 3. A quite remarkable, if not actually too precise, concurrence of the geographical ranges of the two species seems apparent, even with regard to most disjunct areas. The coincidence of distributions, plus the seemingly identical habitats, underscores a taxonomic question regarding the specific distinctness of *R. truncata* vs. *R. tenerrima,* but an in depth consideration of such problems is beyond the scope of this paper.

Possibly both *R. truncata* and *R. tenerrima* represent taxa that may be more overlooked than rare in Saskatchewan and Canada. Both species should be further searched for in the more southern parts of the three Canadian Prairie Provinces and British Columbia.

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A Comparison of Two Techniques for Assessing the Impact of Pesticides on Small Mammals

G. A. BRACHER,[1,3] P. D. KINGSBURY,[2] and J. R. BIDER[1]

[1]Department of Renewable Resources, Macdonald Campus of McGill University, Ste-Anne de Bellevue, Quebec H9X 1C0
[2]Forest Pest Management Institute, Canadian Forestry Service, P.O. Box 490, Sault Ste-Marie, Ontario P6A 5M7
[3]Author to whom reprint requests should be sent. Present address: 536 Beaconsfield Blvd., Beaconsfield, Quebec H9W 4C9

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The results of two different methods for conducting pesticide impact assessments on small mammal populations were compared following an application of aminocarb. The sand transect technique resulted in more reliable results than kill-trapping since it yielded information on a greater number of species, provided a larger volume of data for each species, and caused less disturbance to the small mammal complex. Unlike sand tracking, kill-trapping provided information on the breeding status and age structure of small mammal populations. The inclusion of data from mammals outside the treatment area is a problem common to both methods; but since kill-trapping encourages immigration it may be more subject to this source of error.

Key Words: Small mammals, sand transect technique, kill-trapping, animal activity, impact of pesticides, aminocarb.

In 1978, a co-operative study was undertaken by McGill University and the Forest Pest Management Institute of the Canadian Forestry Service to determine the impact of aminocarb on small mammal populations. Two different methods of pesticide impact assessment were used: the traditional kill-trapping method using snap-back traps and the sand transect technique developed by Bider (1968). Although the data obtained by both methods resulted in the same general conclusion — that aminocarb did not have a severe impact on small mammal populations — we thought it an opportune time to compare the data of the two techniques and discuss the merits of each.

Study Area and Methods

Data were collected using both techniques from a sprayed plot (46° 13′N, 74° 10′W) approximately 22 km southeast of the town of St-Donat, Quebec. The forest covering the glaciated hilly terrain was dominated by Balsam Fir (*Abies balsamea*) and Black Spruce (*Picea mariana*), interspersed with Quaking Aspen (*Populus tremuloides*), Red Maple (*Acer rubrum*), and Sugar Maple (*Acer saccharum*). Major understory species were Bunchberry (*Cornus canadensis*), Raspberry (*Rubus* spp.), Bush Honeysuckle (*Diervilla lonicera*), Wild Lily of the Valley (*Maianthemum canadense*), Aster (*Aster* spp.), Blueberry (*Vaccinium angustifolium*), and Wild Sarsaparilla (*Aralia nudicaulis*). Interspersed throughout the sprayed area were small clearings colonized by grasses (Gramineae), and species common to the forest understory.

The study area lies in the region classified by Trewartha (1943, as cited by Espenshade 1960) as a humid continental climate with cool summers. The temperature of the coldest month averages below 0° C, the warmest above 10° C but below 22° C. Bider (1968) gives a detailed description of the region's climate.

During the summers of 1978 and 1979, animal activity was monitored on 305 m treatment and control transects, 25 km apart. Sand transect construction began with the clearing of vegetation to provide space for a 0.6 m wide styrofoam based tracking surface covered by a 2.2 m high wooden A-frame 2.5 m in width. The styrofoam was placed level to the ground, fastened with wire stakes, and sprayed with a 1:1 tar-gas mixture. This resulted in a pockmarked surface which helped prevent the shifting and loss of fine sand (100–200 mesh; 4 mm deep) spread over the styrofoam. Transparent polyethylene film was stapled to the A-frame to shelter the tracking surface from inclement weather. Bider (1968) provides a description of sand transect construction and maintenance.

Each crossing of a transect was defined as one unit of animal activity. Daily activity totals were used, although the transects were read from 4 to 12 times daily. For nocturnal mammals an activity day began and ended at noon, whereas activity days for diurnal species ran from midnight to midnight. It was not possible to distinguish between the tracks of the Woodland Jumping Mouse (*Napaeozapus insignis*) and the Meadow Jumping Mouse (*Zapus hudsonicus*); consequently, the data for each were combined

and considered as a single group.

Small mammal populations were sampled on treatment and control plots using standard snap-back traps (Victor 4-way®) baited with a mixture of rolled oats, peanut butter, and bacon fat. The distance separating the treatment transect and trapping plot was about 1.2 km. Trapping was carried out during the 5 days immediately prior to the spray, a 6-day period immediately after the insecticide application, and during a 10-day period 23 days after the treatment. Traps were placed at 22 m intervals along parallel lines 22 m apart. The number of traps used varied between trapping periods. Trapped specimens were identified, aged, and sexed. Females were dissected to determine their breeding status.

On 28 June 1979 aminocarb (4-dimethylamino-m-tolyl methylcarbamate) was sprayed over the forest at St-Donat by a Cessna 185 aircraft at an emitted dosage of 0.175 kg/ha.

To determine if there was a relationship between animal activity and the number of animals captured, simple linear correlation coefficients were calculated and tested for significance. Comparisons between data collected by the two methods were only possible for the treatment site because different control plots over 20 km apart were used in the two investigations.

The correlation coefficients for the Meadow Vole (*Microtus pennsylvanicus*) and the Star-nosed Mole (*Condylura cristata*) were not determined as there was insufficient data on which to base the analysis. Also deleted were the days from 1 July to 3 July during the immediate post-spray period since excessive rainfall rendered the sand transects inoperable.

Results

Kill-trapping on the treatment plot resulted in the capture of eight different mammalian species: the Masked Shrew (*Sorex cinereus*), Short-tailed Shrew (*Blarina brevicauda*), Boreal Red-backed Vole (*Clethrionomys gapperi*), Deer Mouse (*Peromyscus maniculatus*), Meadow Jumping Mouse, Woodland Jumping Mouse, Meadow Vole, and Star-nosed Mole. Nineteen species were recorded on the treatment sand transect (Bracher and Bider 1982). The number of daily captures per 100 traps and the corresponding activity data for each species have been summarized in Table 1.

The relation between the daily capture rate and animal activity was not the same for each species (Table 2). Although the correlation coefficients calculated for the Masked Shrew ($r = 0.766$) and Deer Mouse ($r = 0.695$) were significant at the 0.01 level, those of the Red-backed Vole ($r = -0.096$) and Jumping Mouse ($r = 0.193$) were not significant. In contrast, the correlation coefficient for the Short-tailed Shrew ($r = -0.473$) was negative and significant at the 0.05 level.

Discussion

Relation between activity and trapping data

The significant positive correlation coefficients calculated for the Deer Mouse and Masked Shrew reveal that similar results were obtained for both these species. As the number of Masked Shrews and Deer Mice crossing the transect increased there was a corresponding increase in the number of individuals captured. Sarrazin and Bider (1973) and O'Neil (1976) noted a similar relation between the activity of the Masked Shrew and the number of captures in unbaited pitfall traps. An inverse relation was indicated by the negative correlation coefficient determined for the Short-tailed Shrew. The number of Short-tailed Shrews captured decreased as activity increased. There was no relationship found between the number of Red-backed Voles or Jumping Mice taken and their activity. This is in direct contrast to O'Neil (1976) who reported a positive correlation between activity and the number of captures of the Woodland Jumping Mouse, yet agrees with the findings of Pellerin (1969) who found no such relationship among Jumping Mice.

Jumping Mice change their rate of activity at different locations under different weather conditions. On nights without precipitation Jumping Mice are active near streams (Thibault 1969), whereas on rainy evenings they are active away from streams (Bider 1968; Pellerin 1969). Therefore, weather and the location of transect and trap sites are extemely important, and as O'Neil's (1976) results indicate, one should not expect a correlation between tracking and trapping data unless the work is carried out on the same site.

In general, it can be assumed that a mammal has a poor likelihood of being trapped when it is not active. However, it does not follow that mammals which are active should be captured if baited traps are used since not all activity is directed towards feeding. When the relation between total numbers captured and total activity for each species is compared (Figure 1) a tendency is noted for Jumping Mice to have a small number of captures relative to the number of crossings. This suggests that Jumping Mice spend a large proportion of their aboveground activity exploring, searching for mates or exercising, rather than foraging. On the other hand, the small number of crossings and the large number of captures reveal that the more fossorial Boreal Red-backed Vole probably does little else than search for food when above the ground. The significant positive correlation coefficients calculated for the Masked Shrew and Deer Mouse indicate that foraging is their main above-ground activity.

TABLE 1. Daily trapping success and activity totals.

	Date	Daily captures per 100 traps							Daily crossings per 305 m						
		Ms	Ss	Bv	Dm	Jm	Mv	Sm	Ms	Ss	Bv	Dm	Jm	Mv	Sm
Pre-spray	24 June	0	0	0	0	0	0	0	135	26	19	10	43	0	0
	25 June	0	0	1.33	0	0	0	0	149	36	30	10	39	0	0
	26 June	1.33	0	0	0	0	0	0	143	27	13	26	46	0	0
	27 June	4.00	0	0	0	0	0	0	150	88	24	9	63	0	0
	28 June	0	0	9.33	0	1.33	0	0	100	23	18	2	59	0	0
Immediate Post-Spray	29 June	0.97	0	0.97	0	0	0	0	162	29	10	17	36	0	0
	30 June	0.97	0	0.97	0	0.97	0	0	205	58	39	50	104	0	0
	*1 July	0	0	2.91	0	0	0	0	—	—	—	—	—	—	—
	*2 July	0	1.94	2.91	0	0.97	0	0	—	—	—	—	—	—	—
	*3 July	0	0	1.94	0	0.97	0	0	—	—	—	—	—	—	—
	4 July	2.91	0	2.91	0	0	0	0	131	6	31	23	23	0	0
Second Post-Spray	22 July	1.30	0.43	2.17	0.43	0	0.43	0	142	18	28	58	39	0	2
	23 July	1.30	0.43	3.04	0.87	0.87	0	0	146	23	35	37	53	0	0
	24 July	6.09	0.87	1.30	0.87	0	0	0	130	14	27	77	27	0	0
	25 July	3.48	0.87	1.30	0.87	0.87	0	0	138	17	17	76	76	0	0
	26 July	4.78	0	1.30	0	0	0	0.43	174	17	61	28	113	0	0
	27 July	5.65	1.74	0.87	1.30	0.87	0	0	206	13	27	37	79	0	0
	28 July	7.39	0.87	2.61	1.74	0.87	0	0	346	20	73	85	339	0	1
	29 July	9.13	1.74	1.30	0.87	0	0	0	451	10	40	129	174	0	0
	30 July	5.65	1.30	0.43	0.87	2.17	0	0	328	9	38	51	91	0	0
	31 July	5.22	0.87	0.43	0.87	0.43	0	0	274	24	86	78	211	0	3
Total		60.17	9.12	30.36	8.69	8.38	0.43	0.43	3516	458	618	803	1715	0	6

Ms = Masked Shrew
Ss = Short-tailed Shrew
Bv = Boreal Red-backed Vole
Dm = Deer Mouse
Jm = Jumping Mouse
Mv = Meadow Vole
Sm = Star-nosed Mole
*1 July to 3 July not included in totals

The small number of captures and the relatively low activity makes it difficult to interpret the results for the Short-tailed Shrew. The Short-tailed Shrew has a lower basal metabolic rate than the Masked Shrew (Buckner 1964); consequently, a greater proportion of their activity can be spent in activities other than foraging. This would explain the low numbers of captures in relation to activity when compared with the results of the Masked Shrew.

TABLE 2. Correlation coefficients showing the relationship between the daily capture rate of animal activity.

Species	Correlation Coefficient
Masked Shrew	0.766**
Short-tailed Shrew	–0.473*
Boreal Red-backed Vole	–0.096(ns)
Deer Mouse	0.695**
Jumping Mouse	0.193(ns)

* — indicates $p < 0.05$
** — indicates $p < 0.01$
ns — not significant

Trapping Effort

Unlike the sand transect technique, kill-trapping did not provide sufficient data on any one species to make statistical inference. Trapping results for all species were combined and the impact of the pesticide determined on the small mammal complex as a whole. Because the susceptibility of animals to a toxin can vary widely, even for closely related species (Tucker and Crabtree 1974; Pimentel and Goodman 1978), the examination of combined trapping results could mask the impact of an insecticide on a particular small mammal population.

Figure 2 shows the relation between the activity of the Masked Shrew and the success of kill-trapping. From the regression line ($y = 0.0227x - 1.0883$) it can be seen that when there is little Masked Shrew activity the number of expected captures is also low. In fact, the relation shows that one should not expect a capture per 100 traps when there is less than 92 crossings/

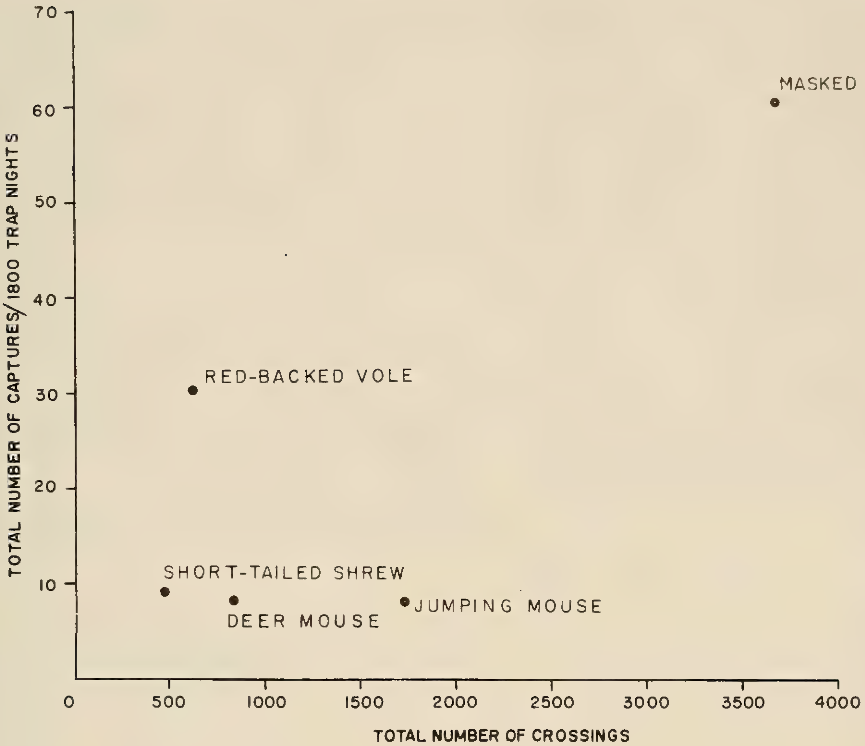

FIGURE 1. Relation between the total mammals trapped for 1800 trap nights and the total number of crossings per 305 m of sand transect during the same time period.

305 m of transect/day. Since the average number of crossings per day was 148 during the pre- and immediate post-spray periods it is not surprising that there were few Shrews captured. The least animal activity tends to occur in early summer when small mammal populations are extremely low. Therefore, trapping effort should be greatest at the beginning of the summer and may be reduced throughout the summer as populations increase. Unfortunately, the least number of traps (75) were used during the 5 day pre-spray trapping period and subsequently increased to 103 and 230 traps during the 6 and 10 day post-spray trapping periods. It would have been necessary to use 460 traps during the pre-spray period in order to obtain a comparable number of captures of Masked Shrews as in the second post-spray trapping period.

Advantages and disadvantages of tracking

The sand transect technique had several advantages over kill-trapping. It permitted each individual in the population to be sampled many times instead of just once as with kill-trapping, and with minimal disturbance to the population. Consequently, there was more data on which to base the impact assessment.

The inclusion of data from nonresident mammals is a problem common to both methods. There is no way of differentiating between mammals originating in or outside the treatment block. The kill-trapping method, however, may be more subject to this source of error. The removal of animals from the treatment area encourages the immigration of others to fill the vacancies left by trapped individuals. Mammals such as the Woodland Jumping Mouse and the Masked Shrew are highly mobile and will rapidly reinvade vacant habitat (Sarrazin and Bider 1973; O'Neil 1976). If data from nonresident mammals are included in data analysis then an impact on the small mammal complex may go undetected.

When using trapping as a means of monitoring small mammal populations, the size and type of trap and the bait used will influence the size, range, and species of mammals captured. Snap-back traps are capable of taking up to Chipmunk-size (*Tamias striatus*) mammals; however, animals of this size are frequently capable of triggering common snap-back traps and avoiding capture. The springing of traps by escaping animals, falling leaves, wind, etc. may result in a sub-

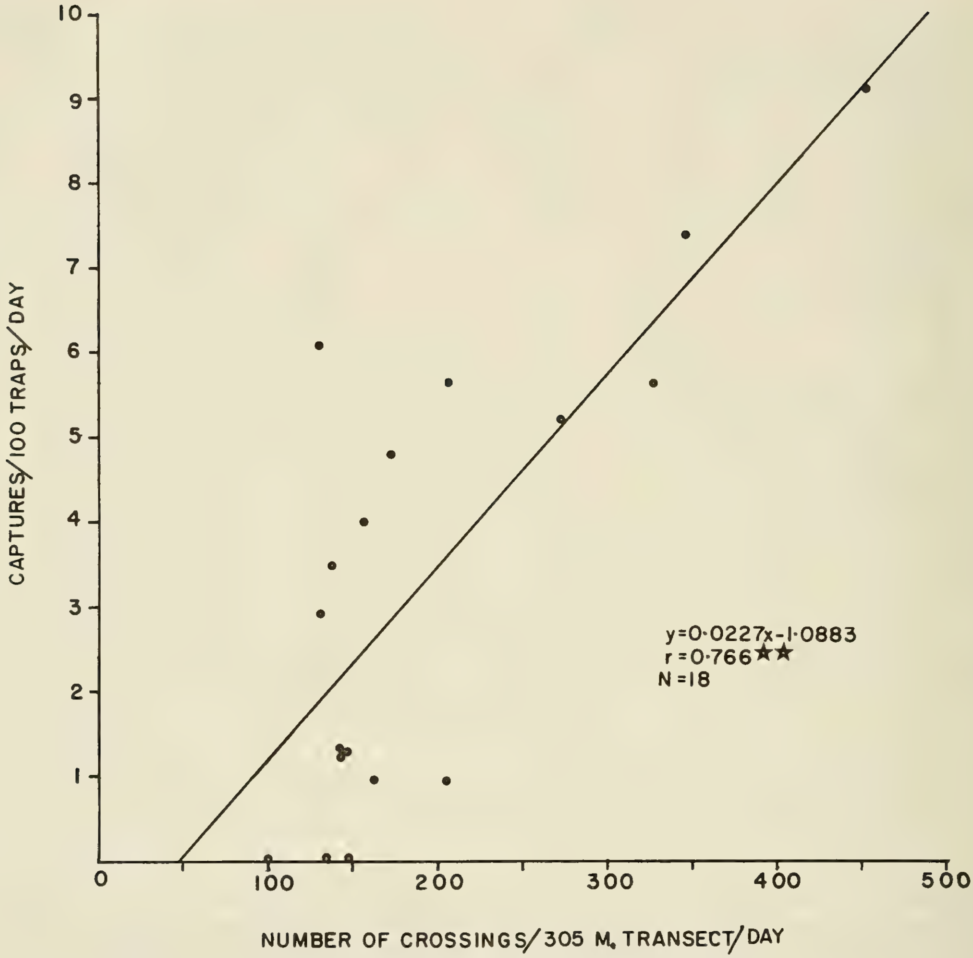

FIGURE 2. Relation between the number of Masked Shrews captured per 100 traps per day and the number of crossings on 305 m of sand transect per day.
★★$p < 0.01$

stantial loss of data in trapping studies. In contrast the sand transect technique yields data on all mammals independent of their size, and simultaneously samples not only populations of mammals but all terrestrial species within the community (Bider 1968; Bracher and Bider 1982). This provides the investigator with information on prey-predator interactions and is useful in determining the secondary effects of an insecticide application.

The main disadvantage of the sand transect technique involve the loss of data due to periods of heavy rainfall and the initial cost of construction. In 1978, the building of 305 m of transect cost approximately $3000 in Canadian funds and required 40 man days of labour. However, the enormous amount of data generated by this method greatly offsets construction costs, and brings the cost per unit of information to a very reasonable level. Also, unlike trapping studies, tracking does not provide specimens for pesticide residue analysis, nor information on breeding status and the age structure of mammalian populations which can aid in the detection of pesticide impacts.

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Winter Habitat Use, Food Habits and Home Range Size of the Marten, *Martes americana*, in Western Newfoundland

M. C. Bateman

Canadian Wildlife Service, P.O. Box 1590, Sackville, New Brunswick E0A 3C0

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Habitat preferences of Marten (*Martes americana*) were determined from 51.6 km of snow tracking during the winters of 1980-81 and 1891-82. Marten selected mixed Balsam Fir (*Abies balsamea*) -White Birch (*Betula papyrifera*) stands and coniferous forest with high (⩾ 76%) overstory density. Marten travelled almost exclusively on the snow surface in winter but frequently investigated subniveal tunnels by blowdowns and stumps. These access points may be important in prey accessibility. The most important prey species in winter were Snowshoe Hare (*Lepus americanus*) and Meadow Vole (*Microtus pennsylvanicus*) which were identified in 51.8 and 30.4 percent of 56 scats analysed. Red Squirrel (*Tamiasciurus hudsonicus*) was not found in scats although it was present in the study area. Winter ranges, as determined by radio telemetry, were 27.5 km² and 17.7 km² for a male and a female marten.

Key Words: Marten, *Martes americana*, Newfoundland, food habits, habitat selection, home ranges.

Habitat use, food habits and home range size of the American Marten (*Martes americana*) have been studied in many areas of North America, but never on the Island of Newfoundland. Prey species diversity and abundance on Newfoundland are lower than those on the mainland. Because of this, food habits and home range sizes of Marten on the Island were also expected to differ from the mainland. This study was designed to determine winter habitat use, food habits and home range sizes of Marten on Newfoundland.

Study Area

The 80 km² study area was located along Southwest Brook approximately 40 km east of Stephenville on the road to Burgeo. Topography was moderately rugged, with steep slopes from the barren hilltops to the lowlands. Slopes on the east end of the study area were more gentle although hilltops were as high as, or higher than, in the western part. Elevations ranged from 60 m above sea level at Southwest Brook to about 512 m asl. Most streams originated in upland ponds and flowed swiftly down steep slopes.

The study area was within the Corner Brook Section of the Boreal Forest Region of Canada (Rowe 1972). Tree growth was good; dominant species were Balsam Fir (*Abies balsamea*) and Black Spruce (*Picea mariana*). Forests occurred on the slopes and in the valley and rock barrens occurred on the hilltops. Softwood scrub frequently grew between the rock barrens and the forest, and on poor sites on the lowland. Except for a small part of the study area cut in 1981, forests had never been cut and were predominantly mature or overmature. Areas of windfall were common. Cover types on the study area were as follows: Balsam Fir forest — 28%; Balsam Fir-Black Spruce — 10%; Black Spruce-Balsam Fir — 10%; Balsam Fir-White Birch (*Betula papyrifera*) — 2%; softwood scrub — 25%; hardwood (White Birch, Yellow Birch (*Betula alleghaniensis*) — White Birch) — 5%; and Black Spruce stands — 2%. Lakes, islands, rock barrens and bogs covered the remainder of the area.

Snow cover in the study area occurred from November-December through April-May. Snow thickness in this area frequently exceeds 1.5 m and total snowfall can approach 600 cm annually. The average yearly temperature was near 1°C and the average maximum and minimum approached 6°C and −3°C, respectively.

Methods

Winter habitat use was determined by tracking during the winters of 1980-81 and 1981-82. Marten tracks in snow were followed or back-tracked and the distances travelled in each habitat type estimated by pacing. Evidence of kills, subnivean investigations and resting sites were recorded. Habitat classifications (forest cover type) were based on forest cover maps prepared by the Newfoundland Department of Forestry and Agriculture. This classification describes stands by canopy composition and canopy density, unforested areas of softwood scrub, rock barren and open (bog, road and power line right-of-way). Overstory density categories were high (⩾ 76%), moderate (51–75%) and low (26-50%). Marten use of areas of blowdown were recorded separately although those areas were not mapped. A selection index, the ratio of per cent of

km of marten trail to per cent of habitat available, was calculated for habitats used by Marten (McCord 1974).

Small mammal snap-trapping was used to compare relative abundances of Masked Shrews (*Sorex cinereus*) and Meadow Voles (*Microtus pennsylvanicus*) in selected habitat types. Trapping was carried out between 29 August and 9 September 1980 and 1 September and 9 September 1981. Traplines consisted of 100 traps and were operated for four consecutive nights. Results were expressed as catch per 100 trap nights (TN) and were corrected for sprung traps as recommended by Nelson and Clark (1973).

Marten were trapped with 23 × 23 × 80 cm Tomahawk live traps covered with coniferous branches and birch bark to protect animals from snow and rain. Sardines and dried apples were used as bait. Marten were immobilized with 0.1 cc ketamine hydrochloride (100 mg per cc), and then sexed, weighed and ear-tagged. Radio collars were fitted to selected animals. Collars were prepared by the Canadian Wildlife Service bio-electronics section, Ottawa, weighed 40 g and had life expectancies of 45 wk. In December 1981, trapped Marten were also given an intramuscular injection of penicillin (90 000 I.U.) to prevent infection. Marten were released at the capture site when fully recovered from the drug, 50 to 70 min after injection.

Approximate locations of Marten fitted with radio collars were obtained by triangulation using a hand-held three-element yagi antenna and an AVM LA12 receiver. Locations were plotted on 1:12 500 forest cover type maps. Approximate home ranges were determined by joining the outermost locations recorded (minimum home range of Mohr and Stumpf 1966).

Results and Discussion

Habitat Use

Marten tracks were followed or backtracked for 51.6 km in the Southwest Brook study area from January through March 1981 and 1982. Tracked animals mostly used Balsam Fir (bF) forest with high overstory density. Twenty-six per cent of the length of Marten trails occurred in coniferous forest with moderate overstory density, 23.6 per cent in coniferous forest with high overstory density, 24.0 per cent in coniferous forest with low overstory density and scrub. Twenty per cent of the recorded distance was through Balsam Fir-White Birch (bFwB) stands which represented only 2.3 per cent of the study area. Marten selected coniferous forest with high overstory density and bFwB stands (Table 1). Preference of Marten for dense coniferous forest in winter has also been documented from mainland studies (Koehler et al. 1975; More 1978; Spencer et al. 1983). Koehler and Hornocker (1977) related Marten preference for dense stands to snow depth and condition.

TABLE 1. Marten preference for habitats grouped by overstory density as indicated by snow tracking at Southwest Brook, Newfoundland in 1981 and 1982.

Type	Overstory density*	Per cent of km travelled	Per cent occurrence in study area	Selection index
coniferous	high	23.6	4.7	5.0
coniferous	moderate	26.0	43.0	0.6
coniferous	low, scrub	24.0	26.0	0.9
bFwB		20.7	2.3	9.0
other	open	5.6	24.0	0.2

*high 76%; moderate 51–75%; low 26–50%

About 6 per cent of the length of Marten trails crossed open areas such as road and power line rights-of-way and bogs. Those areas were not used in proporation to their occurrence in the study area (about 24%) but tracks indicated that the animals crossed treeless openings up to 60 m wide. Koehler and Hornocker (1977) and Soutiere (1979) also reported that Marten crossed forest openings. Although Marten are agile climbers, tracks indicated most hunting was done on the ground.

Three beds were discovered during tracking. One was in a knot hole about 1 m from the top of a 12 m high (50 cm dbh) dead stub at the edge of a small opening in bFwB forest. The same Marten which used that site rested during a snow storm in a 7.5 m high (35 cm dbh) stub open at the top and hollow to a depth of at least 1 m. The other recorded nest site was under a snow-covered rock outcrop in softwood scrub.

Twenty-one trap lines sampled Meadow Vole and Masked Shrew densities in five habitats (Table 2). Both species were captured in all habitats. Meadow Vole catches did not differ significantly between habitat types and the highest catch (1.4 voles/100 TN) was in bFwB. Folinsbee et al. (1973) also caught mice in all habitats sampled on Newfoundland and Cameron (1958) reported Meadow Voles throughout woodland as well as grassland there. It is not unusual for Meadow Voles to occur in woodland in other parts of North America (Douglass et al. 1983; Soutiere 1979; Buckner 1957; Grant 1978).

Masked Shrews have been recorded from a wide variety of habitats and tend to prefer high humidities (Folinsbee 1971; Wrigley et al. 1979; Getz 1961). Folinsbee (1971) found Masked Shrew in all habitat types sampled on insular Newfoundland but the spe-

TABLE 2. Capture rates and Chi-square analysis of Meadow Vole and Masked Shrew catches in the Southwest Brook Study Area during summer of 1980 and 1981.

			Observed Catch (catch/100 TN)***		Expected Catch (calculated from proportion of trapnights)		Chi-square Values	
Type	Overstory density**	Number of Trapnights	Meadow Vole	Masked Shrew	Meadow Vole	Masked Shrew	Meadow Vole	Masked Shrew
coniferous	high	1871	18 (1.0)	84 (4.5)	15	62	0.6	7.8
coniferous	moderate	3048	22 (0.7)	98 (3.2)	24	98	0.2	0.0
coniferous	low & scrub	1528	9 (0.6)	42 (2.7)	12	51	0.8	1.6
open		584	3 (0.5)	2 (0.3)	5	19	0.8	15.2
bFwB		727	10 (1.4)	28 (3.8)	6	24	2.7	0.7
							5.1	25.3*

*P ≤ 0.05.
*high ± 76%; moderate 51–75%; low 26–50%.
***corrected for sprung traps.

cies was less abundant in wet boggy areas than in other types.

In this study relatively high Masked Shrew catches were recorded from coniferous forest with high canopy density (4.5/100 TN), bFwB (3.8/100 TN) and coniferous forest with moderate canopy density (3.2/100 TN). The Masked Shrew catch was significantly different (χ^2 = 25.3 d.f. = 4; P ≤ 0.05) among habitat types (Table 2). Shrews were less abundant than expected in open types and more abundant in coniferous forest with high canopy density. That may be the result of high moisture levels under dense conifer canopy.

The habitat types preferred by Marten in winter on the Southwest Brook study area (coniferous forest with high overstory density and bFwB) also had the highest catch indices for Meadow Voles (1.0 and 1.4/100 TN) and Masked Shrews (4.5 and 3.8/100 TN) in late summer. Other researchers have suggested that habitat use by Marten is influenced by prey abundance and availability (More 1978; Douglass et al. 1983; Raine 1983). No information on Snowshoe Hare distribution in the study area is available but the population was at a low level.

Marten often travelled for several meters under the snow in natural tunnels caused by blowdowns, stumps or rocks. Marten may hunt subniveally because small mammals which are an important component of the winter diet often live at ground level under the snow. Tracking data showed that subniveal activity was intensive in areas of blowdown; 42 per cent of 85 subniveal investigations recorded were in blowdown areas and only 7.8 per cent of the length of the trails occurred there.

Marten use of subnivean access points is well documented. Hargis and McCullough (1984), Marshall (1951) and Steventon and Major (1982) reported Marten use of saplings, blowdowns and tree trunks.

Food Habits

Marten feed primarily on small mammals in winter. Microtines, squirrels and lagomorphs are the most important groups in most areas (Remington 1951; Quick 1955; Cowan and MacKay 1950; Koehler and Hornocker 1977; Soutiere 1979; Douglass et al. 1983). Small mammal prey species known to occur in the study area were Snowshoe Hare, Masked Shrew, Meadow Vole and Chipmunk (*Tamias striatus*). Muskrat (*Ondatra zibethicus*) may have occurred in small numbers and Arctic Hare (*Lepus arcticus*) may have been present in the upland barrens. Deer Mice (*Peromyscus maniculatus*) were present in the Abitibi-Price woods camp but were not caught during snap-trapping in the study area (Bateman 1983). Of those species, only the Meadow Vole, Muskrat and Arctic Hare are native to insular Newfoundland.

Analysis of 56 Marten scats collected during the winters of 1981 and 1982 show that the most important prey species on the study area were Snowshoe Hare and Meadow Vole (Table 3). The frequency of occurrence of prey items in scats generally overestimates the importance of weight of small prey compared to large prey (Floyd et al. 1978); therefore, Caribou and Moose carrion were probably more important than indicated. Bird remains occurred in scats as frequently (10.8%) as Masked Shrew (10.7%) but average volumes indicated that shrews were more important.

TABLE 3. Frequency of occurrence and average percent volume of prey items from 56 Marten scats collected in the Southwest Brook Study Area during the winters of 1980-81 and 1981-82.

Item	Number of scats (n = 56)	Per cent frequency of occurrence	Average per cent volume
Meadow Vole	17	30.4	19.5
Masked Shrew	6	10.7	4.6
Unidentified vole & shrew	4	7.1	5.0
Total vole & shrew	27	48.2	—
Snowshoe Hare	29	51.8	38.6
Caribou	4	7.1	0.3
Moose	1	1.8	0.2
Unidentified	3	5.4	4.4
Ptarmigan (*Lagopus lagopus*) or Ruffed Grouse (*Bonasa umbellus*)	3	5.4	0.1
Small bird	3	5.4	1.9

Red squirrels were not identified in scats although they occurred in the study area and are important Marten food in other areas (Marshall 1946; Newby 1951). Shrews have been reported from most North American food habit studies but their occurrence was often less than expected (Soutiere 1979; Koehler and Hornocker 1977; Cowan and MacKay 1950). The frequency of occurrence of shrews (10.7%) in scats from the Southwest Brook study area was higher than in other North American studies possibly because of the few small mammal species available in Newfoundland. Shrews made up 80.4% of the total small mammal catch at Southwest Brook and the capture rate (3.3/100 TN) was also higher than in other study areas (Weckwerth and Hawley 1962; Soutiere 1979; Douglass et al. 1983). The occurrence of Meadow Vole in Marten scats (30.4%) was not exceptionally high: microtines occurred in 36% of the winter samples in Colorado (Remington 1951); 77% in British Columbia (Cowan and MacKay 1950); 27% in Washington (Newby 1951); 84% in Idaho (Koehler and Hornocker 1977); and 14% in Montana (Marshall 1946). There was, however, more than one species of microtine available on those study areas; only the Meadow Vole was present at Southwest Brook. The use of Snowshoe Hare at Southwest Brook (51.8% frequency of occurrence) was among the highest reported (Quick 1955; Remington 1951; Marshall 1946; Hargis and McCullough 1984).

Winter home ranges

Three Marten were fitted with radio collars during fall 1980. One collar was found without the animal in mid-February. The other two collared Marten (one adult female and one adult male) were relocated in the study area 36 and 27 times between 23 November and 7 December 1980, 15 and 26 January 1981, and 26 February and 8 March 1981. Home range sizes were 17.7 km^2 for the female and 27.5 km^2 for the male. The female Marten was located 62 times between 2 and 12 June 1981; most locations were within the home range delineated during winter. The accuracy of home range determinations by any method may be disputed, but such calculations do allow some useful comparisons.

Home range sizes of Marten have been estimated from trapper reports and tracking (Davis 1939; Marshall 1951; Thompson 1949), by live-trapping (Hawley and Newby 1957; Francis and Stephenson 1972; Soutiere 1979) and by radio telemetry (Mech and Rogers 1977; Davis 1983; Campbell 1979; Steventon and Major 1982; Raine 1982). Results of home-range studies differ depending on the technique used. Comparing results from my study with other radio-telemetry study results suggests that Marten in Newfoundland have larger home ranges than those in Maine (Steventon and Major 1982), Wyoming (Campbell 1979), Minnesota (Mech and Rogers 1977) Wisconsin (Davis 1983) and Manitoba (Raine 1982).

The maximum length of home ranges was 13 km for the male and 11 km for the female. Because telemetry was primarily used for determining the home range size, few measurements of daily distances moved are available. However, some maximum recorded straight line distances are of interest. The male moved 6.8 km in 16 hours on 7 March and 4.5 km in 4 hours on 21 January. The female moved 5.4 km in 16.5 hours on 7 March and 3.4 km in 6 hours on 27 February. Taylor and Abrey (1982) reported similar movements by Marten in Algonquin Provincial Park, Ontario.

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New Records of Snapping Turtles, *Chelydra serpentina*, and Painted Turtles, *Chrysemys picta*, from New Brunswick

DONALD F. MCALPINE[1] and GILLES GODIN[2]

[1]Natural Science Department, New Brunswick Museum, 277 Douglas Avenue, Saint John, New Brunswick E2K 1E5
[2]New Brunswick Department of Forests, Mines and Energy, P.O. Box 170, Bathurst, New Brunswick E2A 3Z2

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The Snapping Turtle, *Chelydra serpentina*, and the Painted Turtle, *Chrysemys picta*, formerly regarded as restricted to the lower Saint John River Valley and the Grand Lake region (Herpetofaunal Section 2A) within New Brunswick, are documented to be much more widespread on the basis of 20 new localities for the former and 8 new localities for the latter. Herpetofaunal Section 2A in New Brunswick now has only one species of amphibian or reptile unique to that section, the Gray Treefrog, *Hyla versicolor*, but may contain the highest Painted Turtle densities in the Province. Although Snapping Turtles and Painted Turtles are now widely reported from Herpetofaunal Section 3A, they are still unknown from Section 4A in New Brunswick.

La Chélydre serpentine, *Chelydra serpentina*, et la Tortue peinte, *Chrysemys picta*, qu'on croyait autrefois limitées à la vallée inférieure de la rivière Saint-Jean et à la région de Grand Lake (Section herpétofaunique 2A) à l'intérieur du Nouveau-Brunswick, sont beaucoup plus répandues que prévu, selon la documentation recueillie dans 20 nouvelles localités pour la première et 8 nouvelles localités pour la seconde. La section herpétofaunique 2A, au Nouveau-Brunswick, ne possède maintenant qu'une seule espèce d'amphibiens et de reptiles unique à cette section, la Rainette versicolore (*Hyla versicolor*), mais pourrait avoir les plus fortes densités de Tortues peintes de la province. Bien que les Chelydres serpentines et les Tortues peintes aient été signalées dans la majeure partie de la section herpétofaunique 3A, elles sont encore inconnues dans la section 4A, au Nouveau-Brunswick.

Key Words: New Brunswick, distribution, Snapping Turtle, *Chelydra serpentina*, Painted Turtle, *Chrysemys picta*, Herpetofaunal sections, environmental temperature indices.

The Snapping Turtle, *Chelydra serpentina*, and the Painted Turtle, *Chrysemys picta*, in New Brunswick have been postulated to represent relict populations from a more extensive distribution during the post-Wisconsin hypsithermal (Bleakney 1958a, 1958b). On the basis of field surveys, museum collections and the literature, Bleakney (1958a) stated that the Snapping Turtle was rare and the Painted Turtle was local in the Grand Lake-Saint John River area of New Brunswick and that neither species was known from outside this region in the Province. Subsequently, a number of new observations have been made for both species throughout much of New Brunswick. Cook (1984) mapped some of these but did not document them. These records are listed here in Table 1 and mapped in Figure 1.

The possibility that all, or at least some, of the records reported here represent turtles introduced from other regions of the Province or even from outside New Brunswick cannot be ignored. Turtles are often removed from their natural haunts by people wishing to keep them as pets and their place of origin then becomes difficult to determine, even if they have been marked in some way (i.e., notches or holes in shell, paint on shell) to indicate their previous capture. However, there was no evidence that any of the turtles recorded here were at any time captive. In addition, turtles are long-lived and the possibility of individuals straying and surviving beyond regions of successful reproduction has been suggested by Cook (1984) for northern reports of the Snapping Turtle in Ontario and Manitoba and could be used to explain at least some New Brunswick reports.

Bleakney (1958a) delimited three herpetofaunal sections in New Brunswick as 2A, 3A and 4A. These sections were based on general vegetation, topographic and climatic conditions. They were correlated with the then-known distributional limits or centres of abundance of certain species and with values calculated for environmental temperature indices based on the mean July temperature multiplied by the length of the growing season. The environmental temperature indices for the three sections were 13-12, 12-11, and 11-10 respectively (Bleakney 1958a, p. 39). The southernmost of these sections in New Brunswick was designated 2A "because of the isolated presence in the lower Saint John River Valley and Grand Lake area of *Chelydra serpentina, Chrysemys picta, Hyla versicolor* [the Gray Tree Frog] and *Desmognathus fuscus* [the Dusky Salamander]" (Bleakney 1958a, p. 31)

TABLE 1. Previously undocumented reports of *Chelydra serpentina* and *Chrysemys picta* in New Brunswick. "NBM document" refers to the New Brunswick Museum document files that contain correspondence and, in some cases, photos relating to these records.

No.	Species	Location	Date	Remarks	Documentation
1.	*C. serpentina* x1	Bathurst area, Gloucester County	summer 1977		Christie (1977), C NBM document A. Madden 77-1, 83-1
2.	*C. serpentina* x1	Bartholomew River near Blackville, 46° 40′N, 65°44′W, Northumberland County	summer 1977, 1978, 1982	Taken in Salmon trap, 1977 turtle marked and weighted (14 kg) and recaptured 1978, 1982 turtle smaller	NBM document H. Walker 82-1, 83-3
3.	*C. serpentina* x1	Upper Salmon River, 45°36′N, 64°57′W, (Border of Fundy National Park) Albert County	summer 1966		Majka (1968)D
4.	*C. serpentina* x1	Belleisle Creek, Springfield, 45°41′N, 65°49′W, Kings County	31 May 1970	Carapace length of 41 cm	Christie (1970)A
5.	*C. serpentina* x1	Lakeville Corner, 45°54′N, 66°15′W, Sunbury County	no date		NBM document Hagmeir 84-1
6.	*C. serpentina* x1	Saint John River, Victoria County	no date		NBM document Hagmeir 84-1
7.	*C. serpentina* x1	Digdeguash River at Elmsville, 45°16′N, 67°01′W, Charlotte County	16 March 1982	Sunning on riverbank	NBM document D. Clark 82-1
8.	*C. serpentina* x2 *C. serpentina* x1	McAdam, 45°36′N, 67°20′W, York County	1967 June 1981		NBM document A. Madden 83-1
9.	*C. serpentina* x1	Canoose Stream, 45°23′N, 67°25′W, Charlotte County	1983		NBM document A. Madden 83-1
10.	*C. serpentina* x1	Meduxnekeag River, 46°09′N, 67°34′W, Carleton County	October (?) 1975	Freshly dead at river mouth	*The Woodstock Bugle* 22 October 75 NBM document Bugle 84-1
11.	*C. serpentina* x1	Jonathan Creek, 46°04′N, 64°47′W, Moncton, Westmorland County	June 1967		Squires (1968)F

TABLE 1. Previously undocumented reports of *Chelydra serpentina* and *Chrysemys picta* in New Brunswick (*continued*).

12.	*C. serpentina* x1	Near Magnetic Hill, 46°08′N, 64°54′W, Westmorland County	no date	Small Individual	Squires (1968)F
13.	*C. serpentina* x1	Bartletts Mill, 45°12′N, 67°08′W	24 August 1968	Dead in pond	Squires (1968)F
14.	*C. serpentina* x1	Bath, 46°31′N, 67°36′W, Carleton County	summer 1968		Squires (1968)F
15.	*C. serpentina* x1	Hampton, 45°32′N, 65°51′W, Kings County	no date	Brought into New Brunswick Museum	Squires (1968)F
16.	*C. serpentina* x1	McDougall Lake, 45°19′N, 66°49′W, Charlotte County	4 July 1970		Christie (1970)A
17.	*C. serpentina* x1	Minto, 45°05′N, 66°04′W	June (?) 1954		Squires (1954)E
18.	*C. serpentina* x1	Den Brook, 45°53′N, 66°01′W, Queens County		Trying to climb steep bank, carapace estimated at 46 cm	Christie (1972)B
19.	*C. serpentina* x1 *C. picta*	Nashwaak River, 45°57′N, 66°37′W, York County	no date	At river mouth	NBM document Hagmeir 84-1
20.	*C. picta* *C. serpentina*	St. Stephen (N.B.) — Calais (Maine) area St. Croix River Valley	1890's	*C. serpentina* reported common, *C. picta* rare	Boardman (1903)
21.	*C. picta* x2	Pokemouche River, 47°39′N, 65°02′W, Gloucester County	16 July 1982	Caught in eel trap 26 km below tide-head, both estimated 14 cm total length	NBM document G. Godin 82-2, 82-3
22.	*C. picta* x1	East Point, 47°04′N, 65°21′W, Northumberland County	Summer 1982		*Miramichi Weekend* 13 Aug. 1982 NBM document H. Walker 82-1
23.	*C. picta* x2	Upper Blackville, 46°39′N, 65°52′W, Northumberland County	Summer 1982	Crossing Cains River Road	*Mirimachi Weekend* 19 November 1983 NBM document H. Walker 82-1
24.	*C. picta*	Swan Lake, 45°51′N, 66°17′W, Sunbury County	1966	Reported *C. picta* as .rl.cv-.a0	NBM document A. Madden 83-1

TABLE 1. Previously undocumented reports (*concluded*).

25.	*C. picta*	Oromocto Flats (Oromocto Island), 45°52′N, 66°29′W, Sunbury County	no date		NBM document Hagmeir 84-1
26.	*C. picta*	Bocabec, 45°10′N, 66°59′W, Charlotte County	no date	Its area of chief abundance is apparently the western end of Grand Lake ... but ... there is apparently a small colony near Bocabec	Squires (1968)F

A: D. S. Christie. 1970. N.B. Naturalist 1: 26.
B: D. S. Christie. 1972. N.B. Naturalist 3: 35.
C: D. S. Christie. 1977. N.B. Naturalist 8:42.
D: C. Mijka. 1968. Moncton Naturalist Club Annual Report (1968: 16–19).
E: W. A. Squires. 1954. Nature News N.B. Museum 5. 2 pp.
F: W. A. Squires. 1968. Nature News N.B. Museum 19. 3 pp.

and thus its partial herpetofaunal resemblance to Herpetofaunal Section 2 in Ontario and Quebec. The records presented here indicate that *Chelydra serpentina* and *Chrysemys picta* are both distributed in New Brunswick well outside the Grand Lake — lower Saint John River Valley centre of this section but are still unrecorded from Section 4A. Both Table 1 and Figure 1 suggest, however, that Herpetofaunal Section 2A as originally delimited may support higher densities of Painted Turtles than other regions of the Province. In addition, Alan Madden reports he found *Chrysemys picta* common in the Grand Lake area between 1966 and 1975 (NBM document, A. Madden 83-1). Records for *D. fuscus* from outside Herpetofaunal Section 2A have been reported previously (Cook and Bleakney 1960; C. Majka. 1968. Moncton Naturalist Club Annual Report, pp. 16–19). Only *H. versicolor* still appears to be restricted to Section 2A but this species is documented from only a single marsh within the region (McAlpine et al. 1980), reinforcing the postulation by Bleakney (1958a) that its distribution is more limited in New Brunswick than can be explained by temperature alone.

Bleakney (1958a: 40) found that the northern limit for some eastern species of amphibians and reptiles, including *Chelydra serpentina* and *Chrysemys picta*, but not the Gray Treefrog or the Dusky Salamander, followed an environmental temperature index isopleth rather closely. Elsewhere in eastern Canada the northern limit of the Common Snapping Turtle was generally found to extend to the 11.0 isopleth while that of the Eastern Painted Turtle extended to the 12.0 isopleth (Bleakney 1958a, p. 40), and the new turtle records outside Section 2A reported here fall within these limits.

Cook (1964) and Cook and Folinsbee (1975) suggested the eventual extension of the boundaries of Herpetofaunal Sections 5, 5A, and 6 in Labrador and Quebec because individual indicator species were found to be more widespread than previously suspected. Modifying the boundaries of Herpetofaunal Section 2A in New Brunswick to better reflect the limits of Snapping and Painted Turtles would, however, obliterate most of Section 3A in the Province and obscure regional climatic differences that influence population densities and reproduction. To be of zoogeographic value any boundary changes should be based on better data on relative abundance and reproductive success. F. R. Cook (personal communication) has suggested the possibility that if successful reproduction is established for these newly documented areas, Section 2A might be extended dentrically along river systems, or include isolated populations. This would leave the remaining areas in-between in the climatically less moderate Herpetofaunal Section 3A. As originally defined, however, Section 2A now has only one species unique to it in New Brunswick, *Hyla versicolor*, occurring at only a single location within the section.

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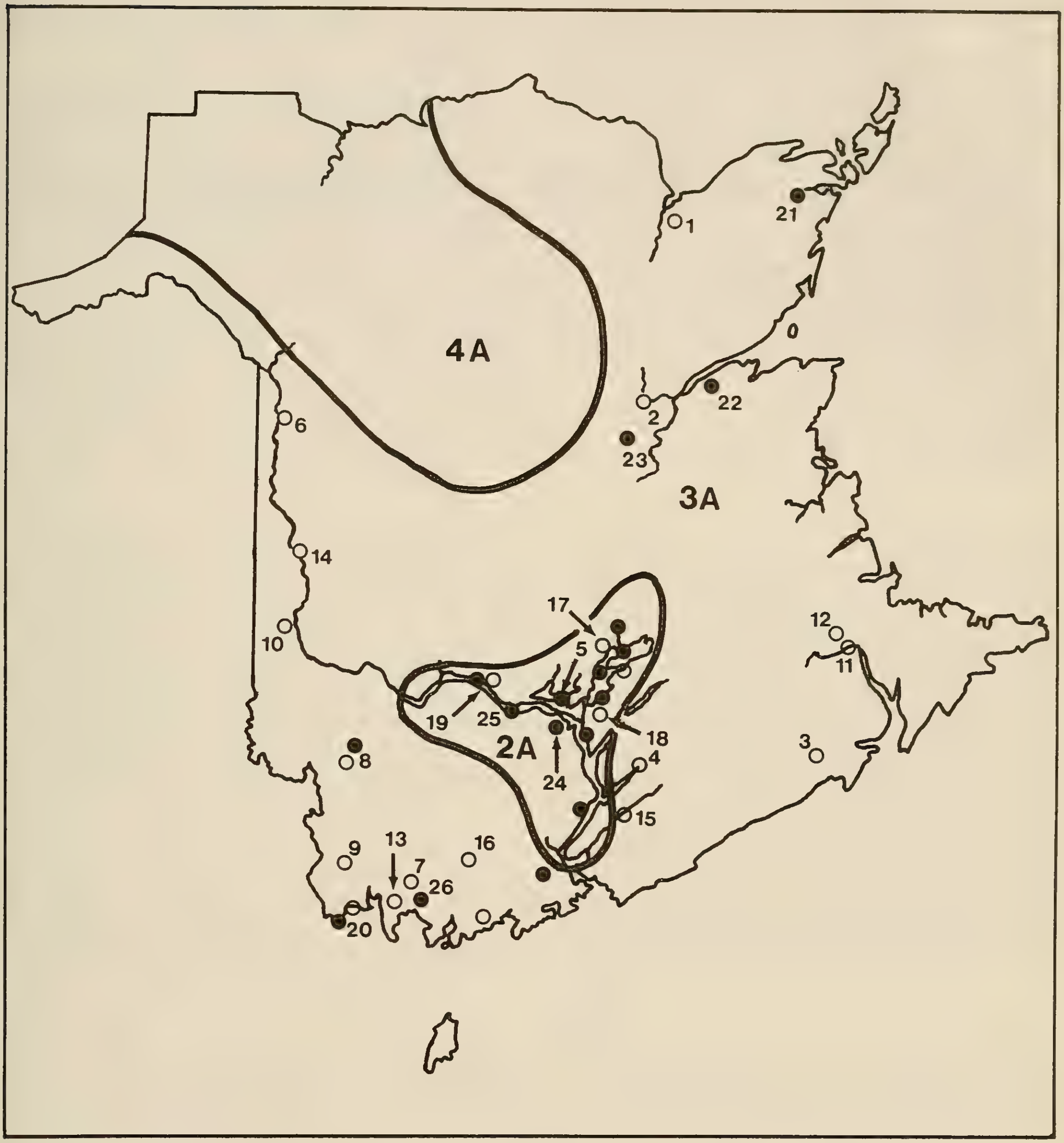

FIGURE 1. Records of *Chelydra serpentina* (open circles) and *Chrysemys picta* (closed circles) in New Brunswick in relation to herpetofaunal sections 2A, 3A and 4A of Bleakney (1958a). Numbers refer to records cited in Table 1. Records lacking numbers are from Bleakney (1958a) and/or refer to specimens in the collections of the New Brunswick Museum or National Museum of Natural Sciences.

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Hummock-Dwelling Ants and the Cycling of Microtopography in an Alaskan Peatland

J. O. LUKEN[1] and W. D. BILLINGS

Department of Botany, Duke University, Durham, North Carolina 27706
[1]Author to whom all correspondence should be addressed. Present address: Department of Biological Sciences, Northern Kentucky University, Highland Heights, Kentucky 41076

Luken, J. O., and W. D. Billings. 1986. Hummock-dwelling ants and the cycling of microtopography in an Alaskan peatland. Canadian Field-Naturalist 100(1): 69–73.

The present microtopography of a subarctic peatland in central Alaska was characterized with respect to various physical and biological characteristics including soil temperature, soil moisture, peat volumetric density, and ant density. A hypothesis is presented to account for the instability of bog microtopography through time. Hummock formation is due primarily to the growth of *Sphagnum* mosses. Hummock retrogression begins with the death of the mosses and is accelerated by the tunneling activities of ants. Ants are limited primarily to the warm, dry, senescent hummocks. A stratigraphic record spanning 1200 years indicated that some hummocks have retrogressed and eventually formed hollows. Other hummocks, however, have remained stable without collapsing into hollows. Environmental factors affecting microtopographic succession are discussed.

Key Words: Ants, bogs hummocks, microsuccession, microtopography, moss, *Sphagnum*, peat, *Formica neorufibarbis, Myrmica alaskensis,* Alaska.

Hummocks (raised ground) are common features of the Alaskan landscape. They can be formed as a result of cryoturbation, which is the heaving of soil by frost. Hummock-hollow microtopography can also result from the growth of tussock-forming plants of *Eriophorum* (Cottongrass) or mound-building *Sphagnum* mosses. The thermal advantages of a raised growth form in temperature-limited ecosystems are known (Chapin et al. 1979), but only a few attempts have been made to document successional patterns in hummocky terrain (Billings and Mooney 1959).

Data are presented here to support the hypothesis that hummocks in *Sphagnum*-dominated peatbogs are unstable and subject to change through time. In addition, we propose that the instability of microtopography in an Alaskan peatbog is influenced to a considerable extent by hummock-dwelling ants.

Study Area

Our research site was situated in a large peatbog (ca. 15 km^2) underlain by permafrost near Fairbanks, Alaska (64°52′N, 147°46′W). The vegetation of this bog is characteristic of many of the lowland muskegs that occur throughout central Alaska and Canada. The open tree layer consists of stunted Black Spruce (*Picea mariana*) with a shrub and herb layer dominated by *Ledum palustre* subsp. *decumbens* (Labrador Tea), *Vaccinium vitis-idaea* subsp. *minus* (Mountain Cranberry), and *Rubus chamaemorus* (Cloudberry). The peat stratigraphy indicates 30-60 cm of *Sphagnum* peat overlying a deep basal accumulation of peat composed largely of vascular-plant remains.

The surface of this peatland is a mosaic of hummocks and intervening depressions or hollows. The hummocks result from the growth of *Sphagnum magellanicum* and *S. fuscum*. These two moss species form hummocks because they grow in tight stands that resist compaction by snow and gravity. *Sphagnum angustifolium* and *S. lenense* occupy the hollows.

In addition to active hummocks and hollows, we observed a number of senescent hummocks. These hummocks no longer supported living populations of *Sphagnum*. They were instead covered by a lichen crust dominated by *Cladonia* and *Cetraria* spp. When a number of these senescent hummocks were cut open, most showed evidence of tunneling by ants. Some contained active nests of the ant *Formica neorufibarbis* while foraging ants (*Formica neorufibarbis* and *Myrmica alaskensis*) were evident throughout the peatland.

Methods

Three microhabitats (active hummock, senescent hummock, and hollow) were selected for a study of microclimate and ant distribution during spring and summer of 1983.

Physical Characteristics

Seasonal heat sums for the three microhabitats were measured by using Moeller distance thermographs. A single thermograph probe was placed at -5 cm in each of the microhabitats. Soil-moisture samples (0-5 cm depth) were collected from the different microhabitats. They were taken to the laboratory and oven-dried at 70° C so that soil moisture could be expressed as a proportion of the oven-dry weight.

Estimates of peat volumetric density were obtained by cutting samples of peat with a known volume from the 0-5 cm zone of each microhabitat. A stainless steel coring device was used to cut the samples. They were taken to the laboratory, oven-dried, weighed, and volumetric density was expressed as g dm^{-3}.

Ant Distribution

The density of foraging ants outside the nests was estimated during the third week of July, 1983. Peat blocks, 100 cm^2 at the top and 15 cm long, were cut from the different microhabitats, bagged, and taken to the laboratory. Ants were removed from the peat with an aspirator and then counted.

The nests of *Formica neorufibarbis* were located by marking individual ants and then following them back to the nests. The nests were cut from the peat with a knife and taken to the laboratory where the ants were counted. Active nests of *Myrmica alaskensis* could not be located.

Peat Stratigraphy

A trench 7 m long was dug to the depth of permafrost so that horizons of peat could be mapped and peat samples collected for later identification of *Sphagnum* macrofossils. Fourteen intact profiles were cut from the peat face, two from each 1-m section. Each profile was ca. 5 cm on a side and extended from the soil surface to the permafrost. In the laboratory, dominant *Sphagnum* species in visible horizons were identified by staining and sectioning. When stem leaves could not be found, branch leaves were used. These were compared to voucher specimens in the Duke University Cryptogamic Herbarium.

Results

Ant Distribution

In mid-July, 1983, below-ground foraging ants outside the nests were found in significantly higher densities in senescent hummocks as compared to active hummocks and hollows (Table 1). Ant nests were found only in senescent hummocks and the mean number of ants in the nests of *Formica neorufibarbis* was 84.4 ± 4.0 (SEM, n = 6).

Microenvironment

Senescent hummocks were the warmest of the three microhabitats (Table 1) as measured by continuously recording thermograph probes at depths of -5 cm. Proximity to the water table, permafrost and the presence of living populations of *Sphagnum* maintained cooler, wetter conditions in hollows and active hummocks (Table 1).

Ant nests in this peatbog are structures characterized by a series of tunnels and chambers lined with macerated *Sphagnum* tissue. In the 0-5 cm zone below the soil surface, where most ant tunnels are located, volumetric density of peat in senescent hummocks was higher than that of living populations of *Sphagnum magellanicum* on active hummocks and less than that of peat in the hollows (Table 1). This indicates partial peat collapse on senescent hummocks and maximum peat collapse in the hollows.

Peat Stratigraphy

Throughout most of the peat face (Figure 1), *Sphagnum magellanicum* was the pioneer of the *Sphagnum*-dominated phase which began ca. 1200 years ago. In longitudinal meters 1 and 2, *Sphagnum*

TABLE 1. Biological and physical characteristics of three microhabitats in a subarctic peatbog during the summer of 1983. All values are means ± SEM.

	Microhabitat		
	Senescent Hummock	Active Hummock	Hollow
Ant density (ants m^{-2})	6.6 ± 1.8 n = 26 a	0.4 ± 0.2 n = 26 b	0.9 ± 0.4 n = 26 b
Peat volumetric density* (g dm^{-3})	40.7 ± 2.9 n = 17 a	24.1 ± 1.2 n = 18 b	61.9 ± 4.3 n = 13 c
Soil moisture* (% dry weight)	240 ± 22 n = 39 a	593 ± 24 n = 39 b	377 ± 29 n = 39 c
Heat sum -5 cm (mean degree days above 0°C)	1695	1507	841

*70°C oven-dry-weight basis, 0-5 cm zone.

Means within rows with different letters are significantly different ($P < 0.05$) (Tukey's test when sample sizes were equal; Newman-Keuls test when sample sizes were unequal).

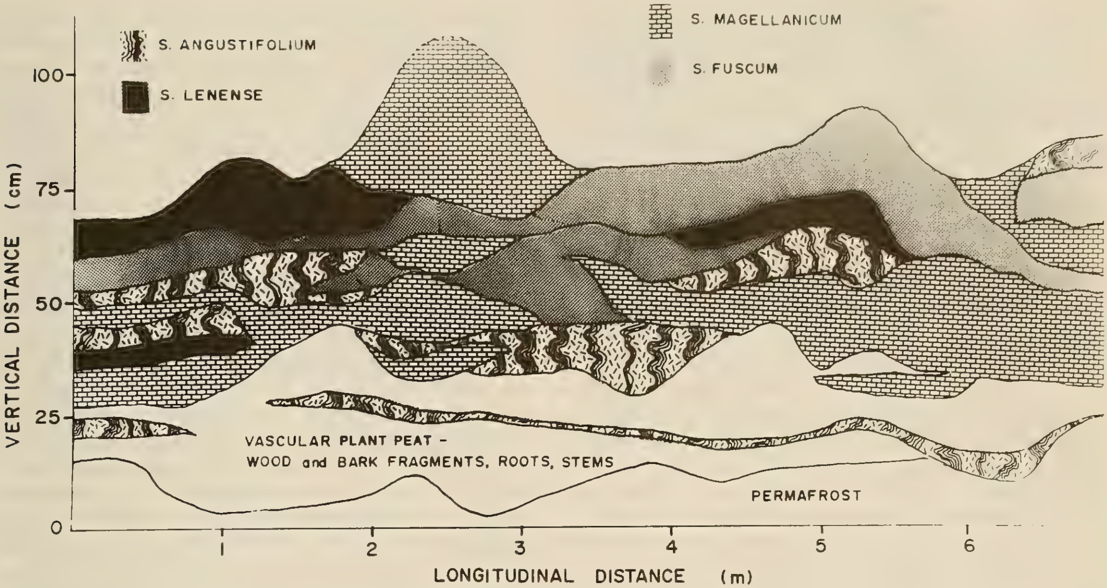

FIGURE 1. Fossil bryophyte and vascular-plant horizons in an exposed peat face. The horizons represent peat in which the bryophyte species indicated by hatching were the major identifiable bryophyte component.

magellanicum has been replaced by other *Sphagnum* species through time, but in meter 3 of the peat face, a *Sphagnum magellanicum* hummock has remained stable with periods of *S. fuscum* invasion. The hummock in meter 3 is now active. In meters 4 and 7, hummock-forming sphagna eventually gave way to hollows while in meters 5 and 6 alternation between hummocks and hollows is evident in the stratigraphy (Figure 1).

Discussion

Although the number of ant species in tundra and taiga ecosystems is low in comparison to that in tropical ecosystems (Kusnezov 1957; Wheeler 1917), the impact of ants on ecosystems can be high if: (1) ants are restricted to specific microhabitats; and (2) sufficient resources are available to support large populations of ants. There is evidence to indicate that ants, as a result of their nest building, can influence vegetation pattern (Culver and Beattie 1983; King 1977), soil-nutrient status (Czerwinski et al. 1971; Haines 1975), and soil microbial populations (Jakubczyk et al. 1972). However, data on the ecological effects of ants in peatbogs are scarce though the presence of ants in *Sphagnum* hummocks has been noted (Kannowski 1967; Matthey 1971).

Based on our observations, we propose the following word model for *Sphagnum* hummock development: (1) hummock-forming *Sphagnum* mosses engulf the branches of woody, perennial shrubs; (2) adventitious-shoot formation by the shrubs is stimulated by the encroaching *Sphagnum* carpet, thus reinforcing the hummock structure; (3) if the hummock-building *Sphagnum* mosses die, then the hummock may resume growth at some later date when the moss populations are regenerated, or, the hummock may collapse and form a hollow; (4) hummock collapse is facilitated by the tunnel-building activities of ants.

Sphagnum mortality and the eventual onset of senescence in hummocks may occur for several reasons. The hummocks simply grow so far from the water table that the moss capitula no longer remain hydrated. Modifications of *Sphagnum* morphology as a result of vascular-plant shading (Hayward and Clymo 1983) might also contribute to a decrease in the ability of the mosses to remain hydrated. In this case, the ants would colonize the hummocks after *Sphagnum* death. It is possible, of course, that ant tunnels in the 0–5 cm zone of the *Sphagnum* carpet are responsible for breaking the continuity of the water column from the water table to the growing capitula. In this scenario, the ants, or more specifically ant nests, would be the cause of *Sphagnum* mortality as well as hummock collapse.

Hummock retrogression can be simply a physical process in which hummocks collapse upon themselves due to the weight of snow in winter. Such a collapse would be accelerated when ant nests have weakened

the internal structure of the hummocks. An imbalance in the carbon budget may also be a cause of hummock retrogression. If more carbon is lost via decomposition than is gained via net primary production, then the hummocks will lose mass and eventually disintegrate. Although *Sphagnum* tissue is resistant to decomposition, physical and chemical modifications to the *Sphagnum* tissue as a result of ant nest building probably increase the decomposition rate.

Carbon budgets were calculated for the different microhabitats (Luken 1984). The budgets showed that peat accumulation is not homogeneous across the bog surface; indeed, only the active hummocks accumulate carbon at a rate of 37 g m^{-2} yr^{-1}. Senescent hummocks and hollows are in a phase of disintegration, and are losing carbon at the rate of 3–10 g m^{-2} yr^{-1} (Luken 1984). Thus, all senescent hummocks and hollows at the present time are being overtopped by adjacent active hummocks. The senescent hummocks, if not regenerated, will become hollows.

The regeneration-complex theory of Osvald (1923) proposed that hummocks and hollows tend to cycle from one to the other as peat accumulates. This theory has been supported by some (Dickinson 1975) and rejected by others (Aaby 1976; Walker and Walker 1961). If a cyclic development of hummocks and hollows is present as indicated by the carbon-budget data, then the peat stratigraphy should indicate alternation through time of hummock-forming *Sphagnum* species (*Sphagnum magellanicum* and *S. fuscum*) with those species of *Sphagnum* that do not form hummocks but instead grow in the hollows (*Sphagnum angustifolium* and *S. lenense*). The peat stratigraphy indicates that microhabitat cycling has occurred in the past. On the other hand, microhabitat stability is also indicated in the peat stratigraphy. Why certain hummocks collapse and form hollows while others continue to grow is probably related to the water balance of the hummock-building *Sphagnum* mosses.

The ground structure in this Alaskan peatbog is quite different from the pools and hummocks of European peatbogs that inspired Osvald's regeneration-complex hypothesis. Standing water is not usually present in the hollows. Instead, a perched water table is situated about 30 cm below the moss surface in hummocks and about 15 cm below the surface in hollows. This absence of standing water makes ant dispersal from hummock to hummock a relatively easy task. Therefore, microhabitat preference of the ants is determined solely by microclimate characteristics.

Even though the hollows are closer to the water table, soil-moisture values taken throughout the 1983 growing season indicated that the hollows were actually drier than active hummocks. It appears that active *Sphagnum* hummocks have a greater capacity for water retention or water acquisition. As long as the hummock-building *Sphagnum* mosses remain hydrated, the hummock will continue to grow and the ants will seek other microhabitats. If the *Sphagnum* mosses die, however, then the microclimate becomes more favorable for ant nest building. Provided the *Sphagnum* populations do not regenerate, then a senescent hummock will form and eventually collapse.

We have shown that different microhabitats in this peatbog have different physical and biological characteristics. Most importantly, ant populations are concentrated in senescent hummocks, which are now in negative carbon balance. Conversely, ant populations are absent from active hummocks, which are in positive carbon balance. Thus, there is potential for microhabitat cycling. The real developmental pattern of hummocks and hollows on the peat surface is probably a complex process with hummock inception and overgrowth controlled by the availability of moss populations. Furthermore, hummock growth and death could be modified by the frequency of fires, year-to-year climatic variability, micro-scale variations in water table, trampling by Moose (*Alces americana*), and the activities of ants.

In conclusion, it is the growth of *Sphagnum* hummocks that drives microhabitat differentiation. Varied directions of hummock development may be taken, but it is clear that modifications to the physical environment as a result of hummock growth are important in influencing the distribution of hummock-dwelling ants. A diversity of microhabitats is maintained by the cyclical process of hummock growth, retrogression, and reformation. Without the presence of senescent hummocks, with their relatively warm, dry microclimate, it is unlikely that ants would be able to colonize this ecosystem underlain by permafrost. Conversely, without the presence of ants, it is likely that the rates of microhabitat cycling would be considerably slower.

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The Seasonal Diet of Coyotes, *Canis latrans,* in Northern New Brunswick

G. R. Parker

Canadian Wildlife Service, Box 1590, Sackville, New Brunswick E0A 3C0

Parker, G. R. 1986. The seasonal diet of Coyotes, *Canis latrans,* in northern New Brunswick. Canadian Field-Naturalist 100(1): 74–77.

Coyote (*Canis latrans*) scats were collected from a wilderness area of northern New Brunswick from May 1983 through March 1984. Snowshoe Hare (*Lepus americanus*) was the most important food item in all seasons. White-tailed Deer (*Odocoileus virginianus*) was fed upon in winter and early spring but was of minor importance in summer. Groundhog (*Marmota monax*) was an important food in May and June and raspberries in mid to late summer. Songbirds and small mammals were of minor importance throughout the year. The dependency of Coyotes upon hares and deer in northern wilderness regions is discussed.

Key Words: Coyotes, *Canis latrans*, New Brunswick, seasonal diet.

The Coyote (*Canis latrans*) is a recent immigrant to eastern Canada, first becoming common in New Brunswick around 1973 and expanding into Nova Scotia by 1977. The impact of this new and important predator upon indigenous species, both predators and potential prey, remains uncertain.

The food habits of the Coyote have been studied in many parts of its range, from the arid regions of Texas (Knowlton 1964), Nebraska (Fitcher et al. 1955) and Oklahoma (Litvaitis and Shaw 1980) to the northern forests of Minnesota (Berg and Chesness 1978), New York (Hamilton 1974), Wisconsin (Niebauer and Rongstad 1977), Michigan (Ozoga and Harger 1966), Alberta (Todd et al. 1981) and Maine (Richens and Hugie 1974; Hilton 1976). The only previous study of Coyotes in Atlantic Canada was that described by Moore (1981) and by Moore and Millar (1986). Moore examined carcasses caught by trappers for the age structure and productivity of the sample and he includes tabular data on stomach contents.

In most areas of its range the Coyote is described as an opportunistic predator, living mainly on a diet of rodents and lagomorphs and scavenging the remains of larger mammals, often domestic. Hilton (1976) was the first to study the winter activities and feeding habits of the eastern Coyote in a wilderness area of Maine and also the first to establish the importance of Showshoe Hare (*Lepus americanus*) and White-tailed Deer (*Odocoileus virginianus*) to eastern Coyotes in the winter.

This study complements the earlier work of Moore (1981) and Moore and Millar (1986) and provides further information on the seasonal diet of the eastern Coyote within a wilderness area of northern New Brunswick.

Study Area

Coyote scats were collected from an approximately 130 km² (50 mi²) study area in the extreme northern region of New Brunswick (47°30′N; 67°30′W). The land is owned by J. D. Irving Ltd. and is managed for the production of wood fibre. Much of the mature conifer forest has been harvested and replaced with spruce (*Picea* spp.) and pine (*Pinus* spp.) plantations ≤ 16 years old. The hill tops and slopes support mature Beech (*Fagus grandifolia*), Sugar Maple (*Acer saccharum*) and Yellow Birch (*Betula alleghaniensis*) while mature spruce and Balsam Fir (*Abies balsamea*) are common in the valleys. Cedar (*Thuja occidentalis*) is a common component of riparian and poorly drained sites.

The region is referred to as the Temiscouata—Restigouche Section of the Great Lakes-St. Lawrence Forest Region by Rowe (1972). The climate is more continental than maritime. The summers are normally hot with moderate rainfall while the winters are characterized by low temperatures and considerable snow accumulation.

Materials and Methods

Coyote scats were collected on logging roads and trails from May through November, 1983. From January through March, 1984, field personnel collected scats while following Coyote trails. Individual scats were stored in paper bags and kept frozen. Before analysis, scats were washed in a commercial blender with detergent. The blades in the blender were modified so bones and other fragile items in scats would not be broken. Blender contents were emptied into a sieve (Canadian Standard Sieve Series No. 20; 850 mm mesh opening; The W. S. Tyler Company of Canada, Ltd., St. Catherines, Ontario) and rinsed under a tap. Remaining contents were emptied into a white enameled laboratory tray and the contents sorted manually.

Hairs were identified using a reference collection

and by preparing impressions in a lacquer on slides and comparing scale patterns under a microscope to those in a reference publication (Adorjan and Kolenosky 1969).

Bone, teeth, nail fragments and feathers were also identified by comparing with reference collections. Complete reference skeletons of a number of potential prey species were obtained on loan from the Biology Department of Acadia University. The high possibility for error in many small mammal and songbird identifications required the summation of that data into general categories.

A subjective estimate of percentage mass was given to each item relative to the total material in the tray. Most scats showed some trace of vegetation and this was often attributed to adhesion to the surface of the scat following deposition. Only scats in which vegetation was estimated at 5% or more of the total mass were used for per cent occurrence values.

Results and Discussion

Analysis of 383 Coyote scats showed that Snowshoe Hare and White-tailed Deer were the most frequently consumed food items throughout the year (Figure 1). Vegetation was also commonly consumed, even in winter when grasses and sedges often became exposed along stream edges. In late summer many scats were full of raspberry (*Rubus* spp.) seeds. Small mammals and songbirds were occasionally consumed throughout the year while insects comprised trace components of the diet only during the snow-free period. The Groundhog (*Marmota monax*), a common rodent in the area, was an important component of the diet in spring and early summer. The Groundhog would be easily preyed upon at that time of year when they are conspicuous and vulnerable away from their dens while feeding on the new plant growth.

While Snowshoe Hare remained the major component of the diet at all seasons and varied from 50-80% occurrence, the use of White-tailed Deer was greatest in the winter and least during mid-summer. The high incidence of deer in the May sample is believed to have resulted from the use of carcasses recently exposed by the receding snow cover and did not represent additional direct mortality. Similarly, the high occurrence of deer in January appeared to result from scavenging on carcasses left from the hunting season.

Snowshoe Hare remained the most important food item relative to proportion of contents per scat (Figure 2). Snowshoe Hare comprised 82% of the material in scats containing that food item, followed closely by Groundhog (70%) and White-tailed Deer (66%). Although raspberry was a common food item only in mid and late summer, it was fed upon heavily at that time.

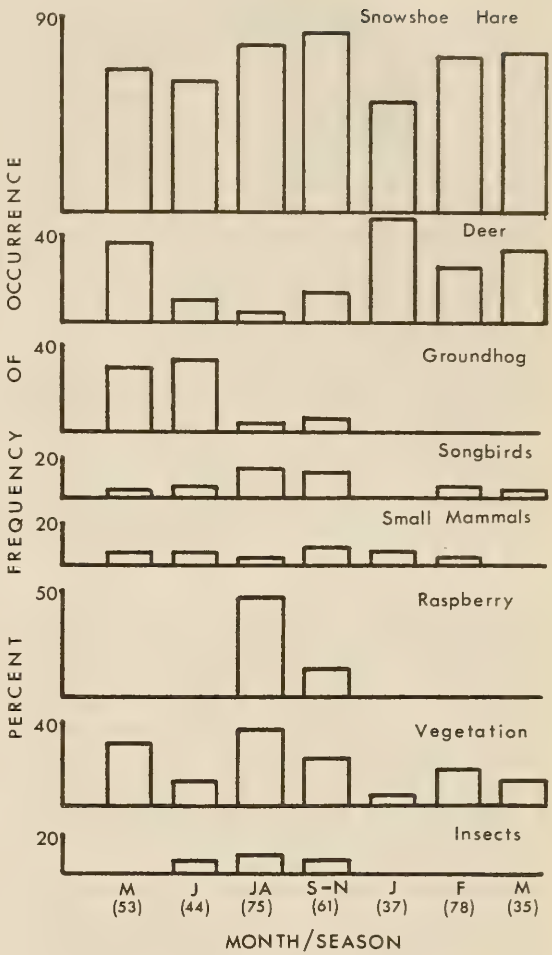

FIGURE 1. The percent frequency of occurrence of major food items in 383 coyote scats collected in northern New Brunswick from May, 1983 through March, 1984 (sample size in parentheses).

Vegetation (mainly grasses and sedges) was most often (higher per cent occurrence) fed upon in summer but the amount consumed per feeding was greatest in winter (48-49% estimated mass in winter; 18% estimated mass in summer). When readily available (summer) Coyotes often ingested small amounts but in winter, when grasses and sedges were less frequently available, greater amounts were consumed per feeding. It is probable that Coyotes, like most carnivores, require a certain amount of plant material to supplement the high intake of animal fibre, especially in winter when diversity in food selection becomes minimal. As suggested by Niebauer and Rongstad (1977)

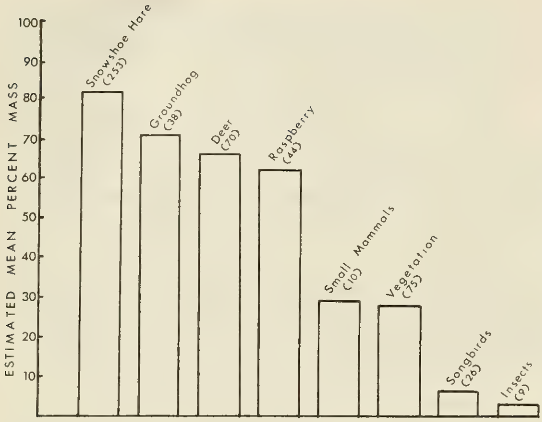

FIGURE 2. The estimated percent mass per scat for major food items identified in coyote scats collected in northern New Brunswick from May, 1983 through March, 1984 (sample size in parentheses).

the bulky vegetation may function as a scour in the digestive tract and serve as a laxative.

This study emphasized the importance of Snowshoe Hare in the annual diet of Coyotes in northern New Brunswick. Although the Groundhog was of seasonal importance, that food source would be unavailable for much of the year. The second most important prey species was the White-tailed Deer which contributed to the diet of Coyotes throughout the year. The low incidence of deer in the June through August samples suggests that predation upon fawns in summer was not of major significance. This is in contrast to results of other studies in more southern regions [Wisconsin — Niebauer and Rongstad (1977); Texas — Knowlton (1964); Oklahoma — Litvaitis and Shaw (1980); Holle (1978); Oregon — Van Vuren and Thompson (1982); Colorado — Ribic (1978)] where predation upon deer during summer was generally greatest.

In more northern and forested portions of its range, food habit studies have documented considerable evidence of deer in winter Coyote scats but most authors attribute that to feeding upon carrion and seldom consider direct predation (Ozoga and Harger 1966; Richens and Hugie 1974; Niebauer and Rongstad 1977).

In Maine, Richens and Hugie (1974) examined stomachs from autumn and early winter killed Coyotes, found deer in 15.9% of the sample and concluded there was no evidence that deer were a stable food. The per cent frequencies of occurrence of hares and deer in Coyote stomachs collected during the autumn and winter in New Brunswick from 1979 to 1981 (Moore 1981; Moore and Millar 1986) were 31.7% and 24.5%, respectively. "Small mammals" was the only other food class with an occurrence value over 10 per cent (14%). Another study in Maine (Hilton 1976) showed that the dependency by Coyotes upon Snowshoe Hare and deer may vary considerably between agricultural and wilderness areas of that state. In remote areas in winter, occurrence values in scats for hare and deer were 40 and 62%, respectively. In summer those values decreased to 29 and 20%, respectively. Tracking studies by Hilton found the frequency of deer killed by Coyotes increased appreciably in late winter.

The results of this study compare well to those of Hilton (1976). The prey-base diversity and winter weather conditions are similar to northern Maine. Although the frequency of deer in New Brunswick scats was less than in Maine, the trend was similar, i.e. increasing importance in late winter and lowest values in summer. The high occurrence of Snowshoe Hare in scats for all seasons in New Brunswick is a result of the high densities of that species. Although deer were common, Snowshoe Hare represented a buffer species, resulting in reduced predation upon deer. Even during the fawning season in June the frequency of deer was low.

This study supports the conclusion by Hilton in Maine that in northern wilderness areas, where winters are often severe and the potential prey base low, the survival of the Eastern Coyote is dependent upon the availability of Snowshoe Hare and White-tailed Deer.

In years of hare scarcity I suggest that Coyote productivity will decline (as in Alberta, see Todd et al. 1981) and predation upon White-tailed Deer increase, especially upon young fawns in early summer and within deer yards in mid and late winter. As that situation has not yet developed in New Brunswick, the impact it may have upon White-tailed Deer populations remains speculative.

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Observations on Dall Sheep, *Ovis dalli dalli*–Grey Wolf, *Canis lupus pambasileus*, Interactions in the Kluane Lake Area, Yukon

MANFRED HOEFS[1], HANNELORE HOEFS[1], and DOUG BURLES[2]

[1]Yukon Wildlife Branch, P.O.Box 2703, Whitehorse, Yukon Y1A 2C6
[2]Kluane National Park, Haines Junction, Yukon Y0B 1L0

Hoefs, M., H. Hoefs, and D. Burles. 1986. Observations on Dall Sheep, *Ovis dalli dalli*–Grey Wolf, *Canis lupus pambasileus*, interactions in the Kluane Lake area, Yukon. Canadian Field-Naturalist 100(1): 78–84.

Described are seven observations of Grey Wolf (*Canis lupus pambasileus*) and Dall Sheep (*Ovis dalli dalli*) interactions documented for the Kluane Lake area during 1982. Three of these interactions resulted in the death of the sheep.

Key Words: Predator–prey interactions, Dall Sheep, *Ovis dalli dalli*, Grey Wolf, *Canis lupus pambasileus*, Kluane National Park, Yukon.

During surveys of the Dall Sheep (*Ovis dalli dalli*) population of Sheep Mountain, Kluane National Park, Yukon (Hoefs and Bayer 1983) carried out to assess winter mortality and lambing rates, six interactions of Grey Wolves (*Canis lupus pambasileus*) and Dall Sheep were observed, three of which resulted in the death of a sheep. One additional pursuit was observed in early August in the Ruby Range, about 10 km northeast of Sheep Mountain. Field notes were recorded incidental to our major investigation on sheep and their range, and therefore lack the analytical approach and the quantification desirable. They have value, however, for comparison with those made by other researchers and are relative to the unusual circumstances this sheep population found itself in because of a very severe winter.

Observations

Abbreviated versions of field notes of these seven observations are reproduced in chronological order. Figure 1 is an aerial photograph of Sheep Mountain and vicinity, on which the locations of six interactions are indicated.

Observation #1

On 5 January 1982, 1140 h, D. B. observed three Grey Wolves on the lower slopes of Sheep Mountain's west face. Temperature was –35°C and visibility was poor because of drifting snow. The wolves came from the east, with one travelling higher up the slope than the others. At 1155 h the wolf noticed a sheep about 100 m above. It gave chase and the sheep immediately ran towards a rock outcrop farther uphill. After about 200 m this escape terrain was reached and the wolf gave up and returned to join the others. They continued to travel in a westerly direction and were later observed near Sheep Creek.

Observation #2

On 1 May 1982, 1000 h, M. Hoefs started to count the sheep on the large southeast facing slope when two wolves appeared from the north at an elevation of about 500 m above the valley floor. From 1000 h to 1115 h, these wolves worked their way over the slope to the south, a distance of about 2 km and then disappeared in the direction of Sheep Creek. Sheep Creek, located about 4 km to the west of the Alaska Highway and separated from Sheep Mountain by a belt of White Spruce (*Picea glauca*) forest about 1 km wide at this elevation (Figure 1), is an important winter range of rams. After completing the survey of the mountain proper, the creek was approached through the forest. At this time (about 1330 h), wolves were howling in the immediate vicinity. Sheep Creek has cut a 30 m deep canyon into the bedrock in its lower reaches and has a narrow belt of grassland along its slopes which is used by rams as winter range. The canyon walls serve as escape terrain. Counts were begun near the mouth of Sheep Creek at 1350 h. The closest band of sheep, consisting of two females, one lamb and a young ram were bedded down only about 70 m upstream at the edge of the forest. Between them and the canyon was a stretch of grassland about 30 m wide.

During the recording of the observation, the sheep suddenly jumped up and ran. Their behaviour reflected surprise and panic, since they bumped into each other and the lamb was knocked over. Two animals were a few steps behind the others, and the last charged at the second last and knocked it over. Only now was it realized that this was a wolf, because of its white colour. The fallen sheep regained its footing once, but the wolf was on it immediately and held it down by stepping on it with his front legs. The other sheep had reached the safety of the canyon; the ewe caught was only 10 m away from the drop-off.

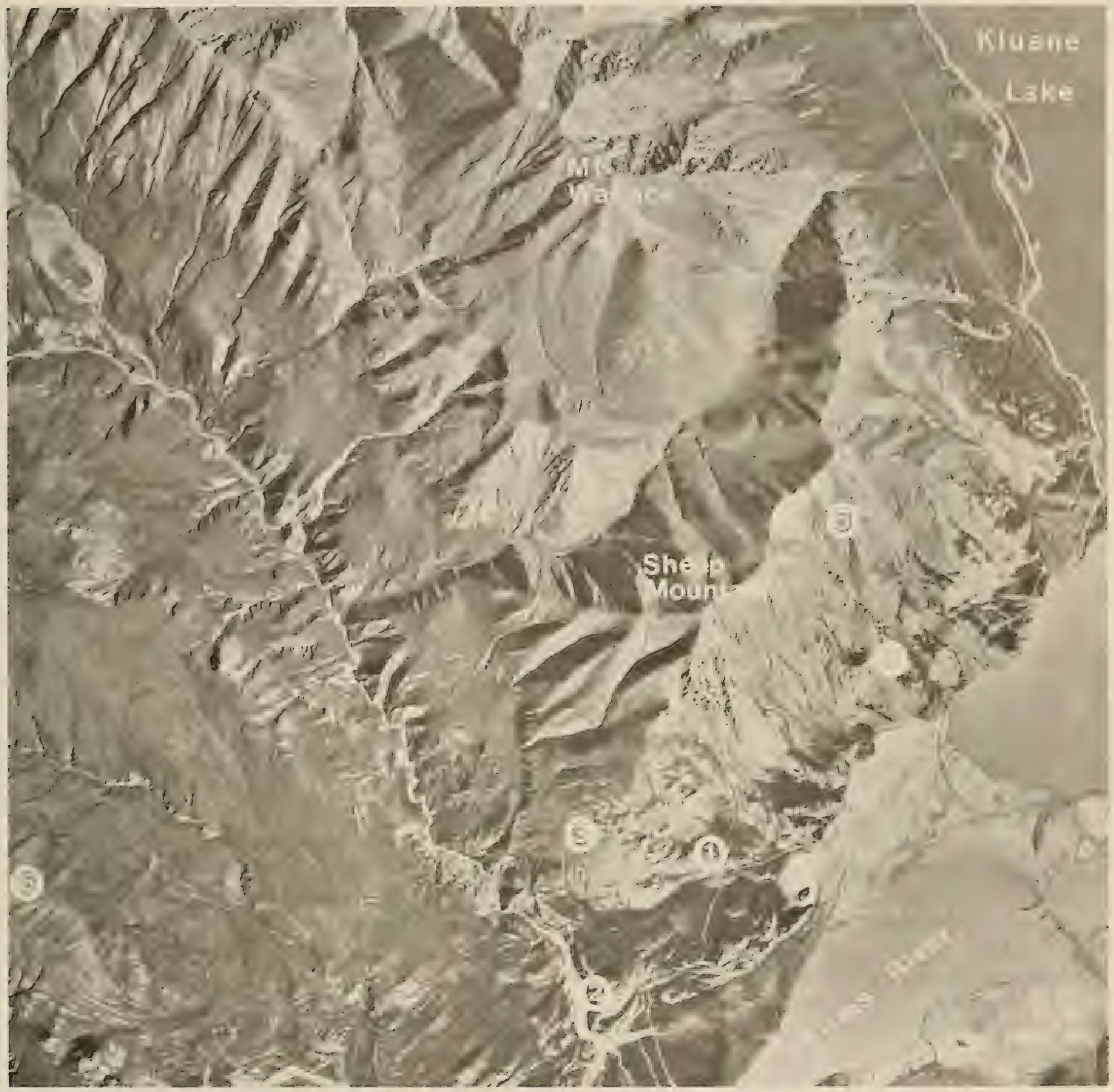

FIGURE 1. Airphoto of study area. Numbers refer to the locations of observations on wolf-sheep interactions in chronological order as discussed in text. Location #7 is omitted because it took place 10 km to the northeast.

The wolf bit the sheep repeatedly in the abdominal region while it continued to struggle. Whenever the sheep lay quietly, the wolf looked at the observer — less than 70 m away and in full sight — and at the other sheep who had climbed out of the canyon and were watching the action only 50 m upslope. The young ram even bedded down. The wolf would take a few steps towards the other sheep, and the downed ewe would kick again. The wolf would return to her and bite her in the back region. This was repeated four times. The wolf finally bit the ewe in the lower portion of the back and shook her viciously, thereby pulling her about 5 m downhill towards the canyon. After this, she did not move again. The ewe was first downed at 1400 h and by 1420 h she appeared to be dead. The wolf stood over the ewe for another 4 min watching the observer and the other sheep, but did not start to feed. It then trotted uphill and disappeared. After about 20 min, the dead ewe was approached by the observer. She was a 13-year-old animal, marked

FIGURE 2. Location of Observation #2 along Sheep Creek. Circle indicates area where sheep were bedded down when wolf attacked. Dotted lines denotes flight path and "X" is the location where ewe was killed.

during the 1970/71 winter. The cut into the abdominal cavity was about 10 cm long, but no organs had been torn out and there was very little bleeding. The ewe was opened to check for pregnancy and to take a rumen sample. The ewe was not pregnant; the viscera were intact, and there was no internal bleeding. The bite into the back appeared to have been the fatal injury. Two fingers could be pushed into the holes created by the wolf's fangs and the splintered backbone was easy to notice. Subsequent analysis of femur bone marrow revealed that the ewe was in poor physical condition. Of interest is that this winter range has so far only been used by rams (Hoefs 1975) and this is the first time that nursery sheep were noticed on it. Rams tend to bed down at the edge of the canyon. Perhaps it was unfamiliarity with the terrain that allowed this surprise attack to happen.

Observation #3

On 15 May 1982, about 1700 h, M. H. and H. H. counted the sheep spread over the large west slope of Sheep Mountain. About twelve ewes and yearlings and two young rams were observed on an area 200 m wide and 100 m high at an elevation of about 1400 m. At about 1703 h, a Grey Wolf approached from the north along a sheep trail. The ewe closest to it was at that time only about 100 m away and grazing near that trail. She was not facing in the wolf's direction. The wolf approached at a trot, and some of the other band members began to run. The ewe did not notice it until the wolf was about 20 m away. She then ran along the sheep trail which followed the contour of the slope more or less horizontally, closely followed by the wolf for about 80 m. The wolf was gaining on her. Instead of turning uphill, as the other sheep had done, she then decided to run downhill for about 60 m and dashed into a depression which was covered by low bearberry shrubs at that elevation, but had willows and other taller shrubs in it further down (Figure 3). The ewe was slowed down by these shrubs and the wolf caught up to her after about an 80 m downhill chase. We could not observe the struggling pair very well in these shrubs, so we decided to hike over to investigate. These observations were made from about 300 m. While we approached the site, the wolf ran out once and made a short dash at two young rams who stood watching about 100 m uphill. However, the wolf gave up its chase immediately and returned to the kill site. It had not noticed our approach because of the hilly nature of the terrain and because the wind was in our favour. When we were about 50 m from the kill site, the wolf came out of the shrubs towards us, then turned around and ran uphill. The killed ewe was a 13-year-old animal, marked during the 1971/72 winter with a neck collar. She was in relatively good shape (based on subsequent bone marrow analysis) and pregnant with a male lamb, almost ready for birth (Figure 5). The only injury on the ewe was a bite on

FIGURE 3. Location of Observation #3 on Sheep Mountain's west slope. Symbols are those used in Figure 2.

the lumbar portion of the back. The backbone was broken. We had arrived at the site at 1730 h, about 15 min after the kill was made. The wolf had not started to feed on the animal. We observed the kill site again on 16 May 1982, 1600 h. By this time, the wolf had returned and dragged the carcass about 100 m downhill. We watched it for about 20 min, after which it left with a large piece of meat. Soon after, three grizzlies approached the kill site from the north and we departed. Again a single wolf was successful in catching a ewe, which had no obvious handicaps. The killing was again executed by biting through the backbone.

Observation #4

On 17 May 1982, 1230 h, G. Calef, M. Broderick, and M. and H. Hoefs were observing sheep on Sheep Mountain's large southeast facing slope. At about 1240 h the sheep on this face began to run in an easterly direction. After some searching, we located a Grey Wolf approaching at an elevation of about 1400 m from the west. It was in no hurry and sat down repeatedly. Judging from the colour, it appeared to be the same wolf observed during the last two days on the west slope of the mountain (Observation #3). The wolf inspected a previous kill site and continued to hunt in an easterly direction. At this time, only one ewe was left on this slope. She was grazing at a lower elevation, about 30 m from a steep canyon. The wolf ran to within about 30 m of the ewe. It then stopped and lay down, digging in and positioning its legs, like a cat before the final jump. The ewe still had not noticed him. The wolf then stood up and backed up, perhaps trying to approach the ewe from a higher elevation. The ewe now noticed it, turned around and ran. The wolf pursued immediately, but did not get close. It lost much distance when crossing the steep canyon. We continued to observe the wolf for another 25 min hunting the slopes east of the canyon. It got very close to a band of seven sheep. This band ran uphill first and then downhill, circling the wolf almost as if playing with it. It repeatedly sat down and watched this band not more than 30 m away, and the sheep stood and watched it. The wolf finally left in the easterly direction about 1310 h. Interesting in these observations were the different reactions the different bands of sheep showed towards the wolf. When the wolf first appeared from the west, it caused all the sheep on the large southeast slope to run, even though the closest sheep was at least 200 m away. Later on, the band it hunted before disappearing from sight let it come to within 20 to 30 m.

Observation #5

On 18 May 1982, M. H. and H. H. had climbed the central portion of Sheep Mountain to an elevation of about 1500 m to observe ewes in the cliffs and to check for newborn lambs. At 1340 h we had located an ewe with a lamb in the cliffs above at an elevation of about 1900 m. She was standing on a sheep trail below steep cliffs and was nuzzling a lamb which was probably born on the previous night. We had not observed it the day before, and it still had the dirty grey colour characteristic of newborn lambs. We had observed this pair through a spotting scope for about 5 min, when a wolf suddenly appeared from above. It

FIGURE 4. Location of Observation #5 in cliffs high above National Parks Information Stand on the Alaska Highway. Attacks and kill locations were one and the same; there was no escape attempt.

FIGURE 5. Marked ewe killed as reported under Observation #3. Arrow points to fatal back injury.

grabbed the lamb by a leg and dragged it about 10 m uphill. The ewe had hardly time to dash away a few meters. The wolf had the same grey colour as the one observed on previous days, and we assumed it to be the same animal. The ewe ran back and forth a few times and even ran toward the wolf once. At this time, it made a rush at her, but followed her only a few meters. It finally left with the lamb in its mouth, and the nature of the terrain precluded further observations. The weights of Dall lambs at birth vary from 3.2 to 4.1 kg (Nichols 1978). This kill took place in extremely difficult terrain usually referred to as 'escape terrain' (Figure 4). Also worthy of note was the defense reaction of the ewe.

Observation #6

At approximately 1340 h, on 3 July 1982, D. B. observed a Grey Wolf travelling rapidly up a drainage gully that led up onto a ridge overlooking Bullion Creek. Three rams were grazing near the top of the ridge. The wolf continued uphill for a short distance and then cut across the slope to another shallow drainage gully that led towards the top of the ridge and the sheep. When it got within 50 m and probably within view of the rams, it crouched and crept forward for 2 to 3 m and then made a dash of about 30 to 40 m towards them. The wolf was amongst the sheep before they could react. It ran almost past one ram and then turned and jumped on his back. At that instant, the sheep turned and began running directly downslope. The wolf followed after with a loose grip on the ram's back, but lost control after 2 to 3 m and fell off, making a head-long somersault down the hill. The sheep continued to run downslope for a short distance and then cut across slope towards a rock outcrop. The wolf lay motionless for 3 to 4 s after its fall before it got up and followed slowly after the sheep. The other two sheep in the group began to run upslope when they became aware of the wolf in their midst, but stopped after a short distance to watch the chase occurring below them. They too headed towards the rock outcrop after the initial chase.

Observation #7

On 3 August 1982, M. H. and H. H. had a camp set up on a 2000 m ridge of the Ruby Range overlooking Kluane Lake. At 1905 h we observed a band of seven ewes and one lamb about 1 km away on another ridge east of us. We had observed this band for about 10 min when two wolves appeared from above. They came to within 30 m of the sheep before being noticed. The sheep then ran downhill, closely followed by the

wolves who fell behind immediately. The only ewe which had a lamb did not run downhill, but climbed into a small rock outcrop. The wolves ran by her not more than 5 m away, following the other sheep. After a 200 m downhill pursuit, the sheep and wolves disappeared from sight — behind the ridge we were camped on. At about 1935 h, we saw six adult sheep running up the mountain to the west of us. Shortly after, we noticed a wolf following them, but more than 200 m behind. The sheep ran up the mountain with apparent ease; the wolf was obviously tired and gave up after a few minutes. The wolf then returned to the ridge we were standing on and joined the other wolf which had bedded down here without being noticed. Having hiked the entire area a few hours earlier, we are convinced that both these observations involve the same sheep, no others being in the area. The wolves had obviously pursued this band for more than 30 min in more or less "rolling terrain" without distinct escape features. This observation revealed that sheep in good physical shape can outlast and outmaneuver two wolves for a considerable length of time.

Discussion

The relatively frequent observations of wolves in the area compared to previous years appears to be a reflection of two factors: (1) The local sheep population had suffered greatly because of a very severe winter and a delayed spring. Sheep were in poor physical shape and 25 per cent of them perished (Burles and Hoefs 1984). The wolves took advantage of this opportunity. (2) Alternate prey sources were scarce. The Snowshoe Hare (*Lepus americanus*), Arctic Ground Squirrel (*Spermophilus parryii*), and the ptarmigan populations had crashed and ungulates other than sheep are rare in the area.

Observations of wolves hunting sheep are rare. We are aware of only two published eye-witness reports as far as thin-horn sheep are concerned. Heimer (1973) reports on a single wolf hunting a Dall lamb. The lamb escaped by hiding in a rock outcrop. Child et al. (1978) observed a single wolf pursuing a Stone lamb (*Ovis dalli stonei*) and ewe. These sheep died by falling down a steep slope, a fate shared by the wolf. Murie (1944) reconstructed a number of wolf-sheep interactions from their tracks left in the snow. Slough (unpublished report on file with Yukon Wildlife Branch, P.O. Box 2703, Whitehorse, Yukon Y1A 2C6) observed a single wolf killing a mature ram in the Ruby Range (137° 55′ W, 61° 14′ N) on 8 August 1983. This documentation is of interest since the kill took place in August, when the sheep are in good physical shape. The wolf pursued the ram for about 800 m, at which time the ram stopped and faced the wolf and was subsequently killed.

In all our observations a single wolf made the kill. Most investigators agree that the hunting strategies applied and the success achieved by wolves are based on "team work" (Murie 1944; Cowan 1947; Haber 1977; Carbyn 1974). Exceptions are reports by Gray (1970) of a single wolf killing a bull muskox, and those by Smith (1970) and Dauphine (1969) of single wolves killing caribou, also documented by Haber (1977).

Investigators agree that a wolf hunting alone can be avoided by healthy sheep on a slope or even on flat areas as long as escape terrain is not far away (Murie 1944; Cowan 1947; Geist 1971; Carbyn 1974). We consider that the observations here represented wolves being able to take advantage of an unusual situation. The indifference shown by other sheep towards the wolf once the kill was made (Observations #2 and #3) has not been previously reported for sheep, but has repeatedly been documented for Barrenground Caribou (*Rangifer tarandus*) (Kelsall 1968; Banfield 1954).

All three kills were made by the wolf running down its prey from above, and by the prey not reaching the safety of the escape terrain. These facts support conclusions drawn by a number of investigators of wolf-sheep interactions (Murie 1944; Cowan 1947; Carbyn 1974; Haber 1977). All emphasize the importance of escape terrain in the anti-predator strategies of wild sheep and Murie (1944) concludes: "As an evolutionary force, the wolf may function most effectively by causing the sheep to dwell in a rocky habitat . . .". "In confining the sheep to the cliffs, the wolf is an important factor in moulding their habitats, and through the past ages has done much to develop and preserve the sheep as we know them today". Observation #5, however, shows that a wolf's ability to maneuver in fairly difficult terrain must not be under-estimated. This site was typical "escape terrain", used over the years on numerous occasions as a lambing area.

The observations that both the ewes appeared to have been dispatched by crushing the backbone has not been reported before as a killing method employed by wolves for larger mammals.

Lastly, the defense reaction of the ewe whose lamb had been taken by the wolf warrants note. During live-capture of newborn lambs for game farms, we have also observed that ewes whose lambs had been caught lose much of their fear of man and approach very closely, sometimes following the capture crew down the mountain side. No similar observations have been recorded in the literature as far as reactions of sheep towards wolves are concerned, but several are reported on sheep–coyote and sheep–bobcat interactions. Hornocker (1969) describes the defense behaviour of three bighorn ewes towards a bobcat, and Berger (1978) gives two instances of maternal defen-

sive strategies employed by parous bighorn ewes towards coyotes. Shank (1977) observed the reaction of three bighorn rams, which formed a muskox-like defense formation towards three coyotes. A similar observation was made by Hoefs (1975) for Dall rams. While this defensive behaviour of the ewe may occasionally help her offspring with other predators, i.e. foxes or eagles, it certainly puts her into considerable jeopardy with large predators like wolves, cougars or black bears and would be selected against.

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Summer Food Utilization and Observations of a Tame Moose, *Alces alces*

CHARLES E. BUTLER

Newfoundland-Labrador Wildlife Division, Building 810, Pleasantville, P.O. Box 4750, St. John's, Newfoundland A1C 5T7

Butler, Charles E. 1986. Summer food utilization and observations of a tame Moose, *Alces alces*. Canadian Field-Naturalist 100(1): 85–88.

Fifty hours observation in summer of a tame Moose indicated food consumption of 28 plant species. Thirty-five per cent of the diet was browse from deciduous trees, 35 per cent forbs and 21 per cent grasses. An additional 72 hours of activity monitoring indicated that the Moose took four resting periods a day.

Key Words: Activity, Brunette Island, summer food, Moose. *Alces alces*.

This paper reports summer food utilization of a tame Moose, *Alces alces*, in Newfoundland. Peek (1976) reviewed 41 Moose food-habit studies in North America and found that the results varied with the availability of species and with winter range conditions, thus emphasizing the need to study Moose food utilization separately for each eco-region. Pimlott (unpublished report, Newfoundland Department of Mines and Resources, 1955) and Dodds (1960) have studied winter food habits of Moose in Newfoundland using a method (modified from DeBoer 1947 and Swift 1948) of counting twigs browsed by moose. This method, however, was not suited for determining herbaceous plants eaten by Moose. No other information has been available on summer food utilization by moose in Newfoundland.

Study Area

Brunette Island (47° 17′N, 55° 55′W) is situated in Fortune Bay, Newfoundland. The island has an area of 20 km² with maximum dimensions 10.3 x 5.5 km.

Brunette Island is in the Boreal Forest Region (Rowe 1972). Stands of Balsam Fir (*Abies balsamea*) 10 m high, interspersed with deciduous shrubs such as alders (*Alnus crispa, A. Rugosa*), Mountain Holly (*Nemopanthus mucronata*), and Wild Raisin (*Viburnum cassinoides*), are dominant on well-drained sites. Prostrate mats of Balsam Fir with some Black Spruce (*Picea mariana*) interspersed with heath shrubs occur on the exposed hillsides and dry sites. Bogs and fens are common on poorly drained sites and are dominated by mosses and sedges (Mercer 1967).

The mammalian fauna of the island includes 70 Caribou (*Rangifer tarandus*), 4 Bison (*Bison bison*) and approximately 1000 Arctic Hares (*Lepus arcticus*). Moose were introduced to Brunette Island in 1974–75 (1 adult male, 2 adult females, 1 yearling female and 3 female calves). The 1980 population was 26 animals.

Methods

A female Moose calf was raised in captivity for a 12-month period at the Salmonier Nature Park, Newfoundland (47° 16′N, 53° 17′W). The calf was suckled by a goat and later weaned to hay-helper cattle feed (Super Sweet Feed Company, St.John's, Newfoundland) which was provided daily. Birch (*Betula papyrifera*) browse was also supplied during the first summer while the animal shared a 0.8 ha enclosure with another Moose calf. From 14 November 1979 to 30 May 1980 the Moose was permitted to roam within a 40 ha portion of the park with natural Moose forage available. The park is located in the Avalon Forest Section — B.30 (Rowe 1972). The dominant tree species is Balsam Fir that rarely exceeds 15 m in height. It forms mixed stands with lesser quantities of Black Spruce and White Birch (W. J. Meades and J. P. Bouzane, 1975. Biophysical classification of the Salmonier Wildlife Park, Newfoundland. Forest Research Centre, St. John's, Newfoundland. Information Report). The Moose was then returned to the enclosure and given birch three times per week, in addition to hay-helper cattle feed. On 17 June 1980, at the age of 13 months, the Moose was immobilized with 0.75 ml Atrovet (Ayerst Laboratories, 1025 Laurentian Boulevard, Montreal, Quebec H4R 1J6) plus 1.0 ml of Immobilon (Reckitt and Colman Pharmaceutical Division, Hull, Great Britain). The animal was then transported to Brunette Island where an activity sensor radio transmitter collar (Telonics, 1048 East Norwood, Mesa, Arizona, U.S.A. 85203) was attached and the animal revived with 2.0 ml of Revivon (Reckitt and Colman Pharmaceutical Division, Hull, Great Britain). For the first 10 days the moose was restricted by a fence to a peninsula (0.9 km²) with habitat typical of the island.

Throughout the study, contact with the animal was maintained via radio telemetry. Food intake was

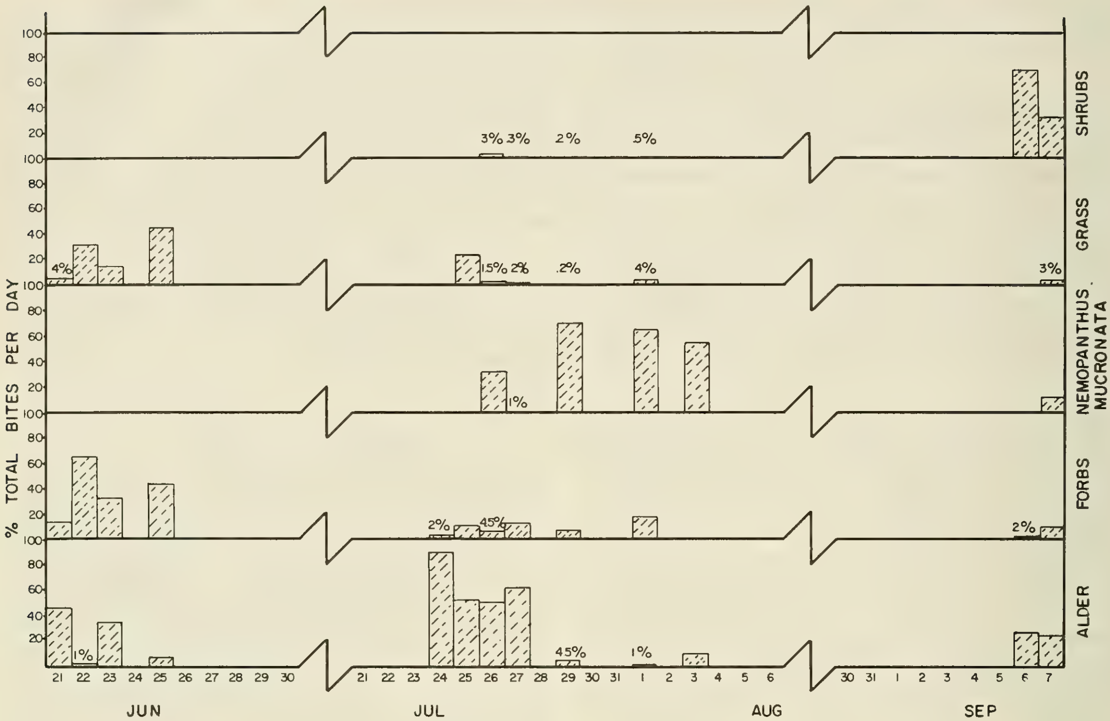

FIGURE 1. Summer food utilization of a tame Moose on Brunette Island.

recorded on tape by the author while standing 1–4 m away.

Moose activity was monitored by listening to pulse rate of the transmitter which differed depending on whether the animal's head was up or down. The pulse rate that corresponded to each activity was determined with a stopwatch by recording the number of seconds per 10 pulse beats while observing the animal. Samples of pulse rate for each activity observed was recorded (resting $\bar{x} = 0.572$ sec/pulse, $S\bar{x} = .006$, n = 14; walking $\bar{x} = 0.679$ sec/pulse, $S\bar{x} = .053$, n = 21; feeding $\bar{x} = 0.822$ sec/pulse, $S\bar{x} = .041$, n = 17). Unpaired t-tests showed significant ($p < 0.001$) differences between each activity, therefore the number of seconds per 10 pulse beats indicated a statistically viable indication of the animal's unseen activity.

Results

A total of 7108 bites was recorded in 50 hours of observation during the period of 21 June to 7 September (Figure 1). Twenty-two per cent of the bites were alder, twenty-one per cent grasses, fifteen per cent bunchberry (*Cornus suecica* and *C. canadensis*), fifteen per cent Canadian Burnet (*Sanguisorba canadensis*) and nine per cent Mountain Holly (Table 1).

TABLE 1. Food (bites) utilization of a tame moose on Brunette Island.

	Food Species	Bites	Per cent of total bites
1	Alder	1593	22
2	Grass	1462	21
3	Bunchberry	1087	15
4	Canadian Burnet	1042	15
5	Mountain Holly	613	9
6	Fir	282	4
7	Sweetgale (*Myrica gale*)	229	3
8	Mountain Ash (*Sorbus decora*)	171	2
9	Ferns	134	2
10	Wild Raisin	117	2
11	Canada Mayflower (*Maianthemum canadense*)	105	1
12	Others[a]	273	4
	N	28	28
TOTAL		7108	

[a]Information available from Depository of Unpublished Data. CISTI, National Research Council of Canada, Ottawa, Canada, K1A 0S2.

Of the twenty-eight species utilized, thirty-five per cent of the diet was deciduous trees, thirty-five per cent forbs and twenty-one per cent grasses.

An additional 72 hours of Moose activity monitoring was obtained in five sessions throughout the summer (Figure 2). There was an average of four resting periods per day. At approximately 0300 h, 0900 h, 1700 h and 2200 h, the duration of rest periods averaged 1.70 h, minimum 0.17 h, maximum = 3.75 h, n = 17.

Discussion

Studies of the food habits of tame White-tailed Deer (*Odocoileus virginianus*) and Mule Deer (*O. hemionus*) indicate that food preferences of tame animals appeared to be similar to those of wild populations (McMahon 1964; Watts 1964; Healy 1971; Neff 1974; Regelin et al. 1976). The author feels therefore that observations made of our tame animal were similar to those of wild Moose.

Le Resche and Davis (1973) observed the feeding

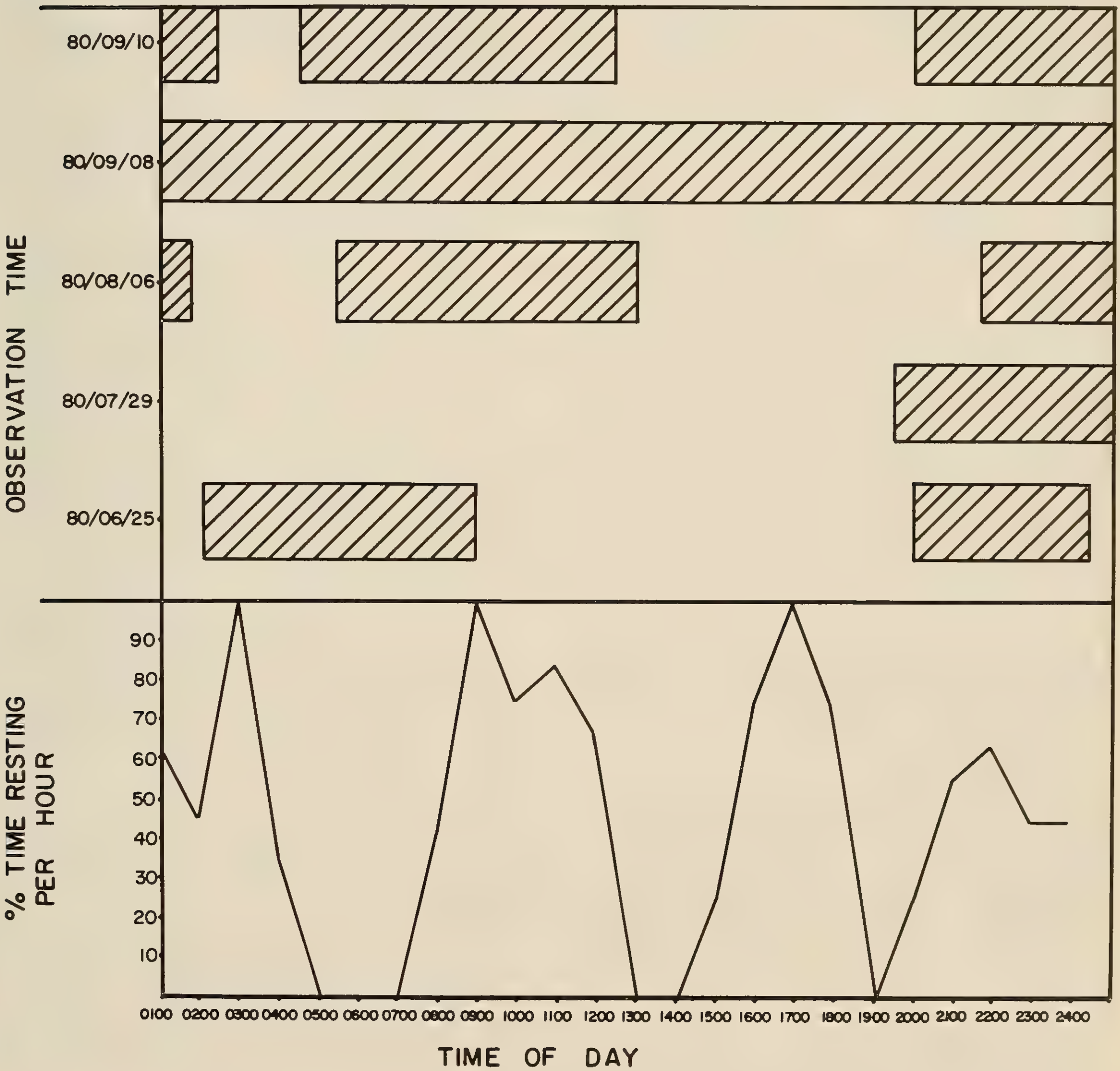

FIGURE 2. Average daily summer activity of Moose on Brunette Island.

habits of three tame Moose in Alaska and found that during summer, 65, 25 and 3 per cent of all bites taken were parts of woody browse plants, forbs, and grasses respectively. Alder, Aspen (*Populus tremuloides*), Low Bush Cranberry (*Vaccinium vitis-idaea*), lichens (*Peltigera spp.*) and mushrooms (mostly *Boletus spp.*) were taken in trace quantities. Consumption of woody browse plants, forbs and grasses differed from results in this study. Moose consume a wide variety of plant species at any one time of year (Miquelle and Jordan 1979) and species composition in the diet changes throughout the year (LeResche and Davis 1973) in relation to seasonal availability as well as morphological and physiological changes in plants.

The study area (20 km^2) provided adequate space for the Moose to choose a natural home range. Van Ballenberghe and Peek (1971) found in Minnesota that the total home range in summer (24 July–22 August) of a yearling female moose was about 9.6 km^2 with 75 per cent of the locations within 2.4 km^2. The Brunette Island Moose utilized a home range of 9 km^2 during the study period. Moose density on Brunette Island approaches that of the highest density areas in the province of Newfoundland, which is approximately two Moose per km^2. Specific effects of high population density on food selection is unknown.

Absence of aquatic feeding by Moose on Brunette Island is noteworthy. Aquatic feeding in the spring and early summer has been documented for Moose in other geographical locations (DeVos 1958; Fraser et al. 1980; Joyal and Scherrer 1978; and others). Although no quantitative analysis of aquatic vegetation has been done, Moose food such as horsetails (*Equisetum spp.*), Buckbean (*Menyanthes trifoliata*), Yellow Pond Lily (*Nuphar variegatum*) and pondweed (*Potamogeton spp.*) exist on the island. Jordan et al. (1973) stated that Isle Royale Moose utilize aquatics as a major source of sodium. The lack of aquatic feeding on Brunette Island might possibly be due to the general availability of sodium, a result of the close proximity of salt water.

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The Biological Flora of Canada
7. *Oxycoccus macrocarpus* (Ait.) Pers., Large Cranberry*

Ivan V. Hall and Nancy L. Nickerson

Research Station, Agriculture Canada, Kentville, Nova Scotia B4N 1J5
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Oxycoccus macrocarpus (Ait.) Pers. is an evergreen, trailing dwarf shrub native to eastern North America. It occurs around the margins of lakes, on bogs, along the edges of stream banks, and along the seacoast, particularly in poorly drained areas behind sand dunes. In Canada, plants flower from the last week of June to the end of July and the berries mature in late fall, generally during the last two weeks of October. Named cultivars are grown commercially in the United States, particularly in New Jersey, Massachusetts, Wisconsin, Washington and Oregon. In Canada the main commercial area is in British Columbia with lesser plantings in Nova Scotia, Quebec and Ontario. The attractive dark red berries are used in the production of sauce and jelly. Currently more than 50 per cent of the crop goes into the production of cranberry juice.

Key words: *Oxycoccus macrocarpus*, Large Cranberry, biology, ecology, physiology, pathology, distribution, economic importance.

1. *Name*

Oxycoccus macrocarpus (Ait.) Pers., section *Oxycoccus*; Ericaceae.
Vaccinium macrocarpon Ait. (Fernald 1950; Gleason 1952; Vander Kloet 1983). This series follows the nomenclature of Scoggan (1979).
Large Cranberry, American Cranberry, Airelle à gros fruits, Gros Atocas (Rouleau 1964).

2. *Description of the Mature Plant*

(a) *Raunkiaer life-form:* Chamaephyte (Scoggan 1950). Evergreen, trailing dwarf shrub growing in bogs, the lee side of dunes (slacks), marshy and poorly drained areas.

(b) *Shoot morphology:* Stems woody, horizontal axes 66.0 ± 6.5 cm long, 1.6 ± 0.2 mm in diameter (n = 11), with numerous upright shoots (15.3 ± 1.6 per plant, n = 11) up to 20 cm high, 0.9 ± 0.0 mm in diameter (n = 25) bearing flowers and fruit; bark greyish brown in late autumn; flower buds terminal, globose and much larger than the vegetative buds; leaves evergreen, alternate in a spiral (Figure 1A), simple, petiolate, 8–15 mm long, 2–5 mm wide, somewhat leathery, pinnately net-veined, margin slightly revolute, oblong, apex and base obtuse, the upper surface dark green, the lower surface with a bloom.

(c) *Root morphology:* Tap root with finely divided rootlets at the extremities (Darrow et al. 1924); adventitious roots occurring along the stems.
(d) *Inflorescence:* Flowers part of a dense cluster with a single floret at each leaf trace (Figure 1B). The individual florets develop in a characteristic hooked pattern resembling the head and neck of a crane, hence the common name is derived from 'craneberry'. Flowers pedicellate; sepals 4, green, deltoid, 2 mm diameter; petals 4, reflexed, separate, pinkish white, length 7.2 ± 0.1 mm (n = 20), width 2.3 ± 0.1 mm (n = 20); stamens 8, in 2 syngenesious whorls; filaments of stamens hairy. Pollen is borne in tetrads (Figure 1D) and shed from the anther through a terminal pore. The ovary is inferior, placentation is axile (Lawrence 1951) with four locules, and the fusion of growth between the ovary and calyx creates a true berry (Fernald 1950). Berries vary in color from white to carmine and in shape from pyriform to globose (Chandler and Demoranville 1959b); up to 3 cm in diameter, and up to 37 seeds per berry (see 7b); acid. Mature seeds are brown (greenish white when immature), elliptic, 1.8 x 1.1 x 1.0 mm, with a finely areolate surface (Montgomery 1977). Fernald (1902) separated *O. macrocarpus* from *O. microcarpus* on the basis of larger stems and leaves, leaves more oval cf. triangular shaped in *O. microcarpus*, a stronger rachis, broader bracts, and larger fruit.

(e) *Subspecies:* None recognized.

(f) *Varieties:* None recognized (Porsild 1938).

(g) *Ecotypes:* Many forms have been identified, described and grown as commercial cultivars (Chandler and Demoranville 1959b).

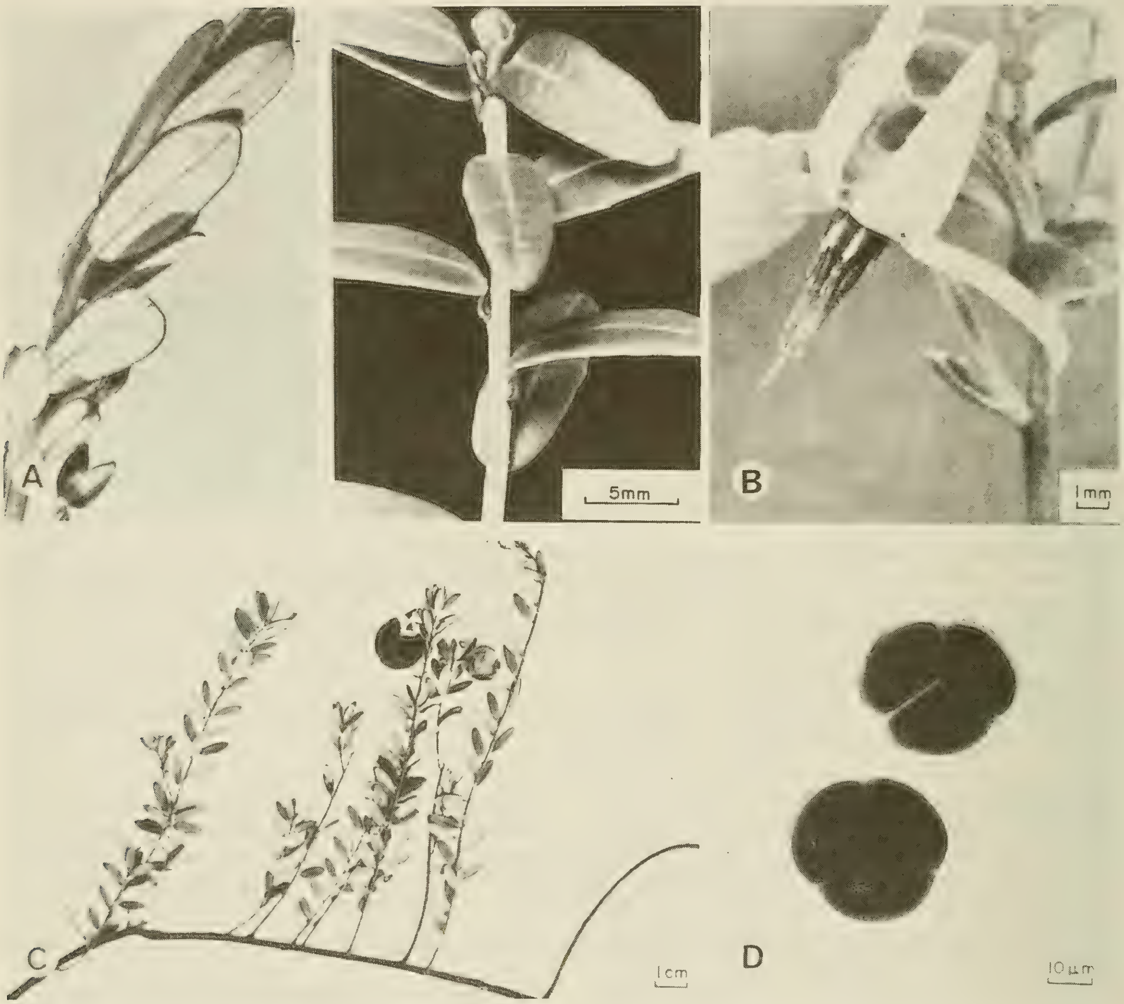

FIGURE 1. Vegetative and reproductive phases of *Oxycoccus macrocarpus* (Ait.) Pers.
A. Two phases of cranberry shoot growth. At the right, the shoot has terminated growth in the formation of a flower bud; the shoot at the left is vegetative. (3X)
B. Cranberry flower. (4X)
C. Cranberry fruits are borne on upright shoots arising from the main stolon. (0.5X)
D. Cranberry pollen. (650X)

(h) *Chromosome numbers:* $2n = 24$ has been reported by Darrow et al. (1944) and Vander Kloet (1983) from plants collected in eastern North America.

3. *Distribution and Abundance*

(a) *Geographic range: Oxycoccus macrocarpus* is native to eastern North America (Macoun 1883) but cultivated in a few other countries. In Canada its range extends from Newfoundland to western Ontario (Figure 2). From its northernmost limit just north of Anticosti Island it extends southward to West Virginia and Tennessee (Ogle 1983) in the eastern United States and to Ohio, Illinois and Indiana in the midwest (Gleason 1952). Local distributions have been published for Newfoundland (Rouleau 1956), Nova Scotia (Roland and Smith 1969), Prince Edward Island (Erskine 1960), Gaspé (Scoggan 1950; Grandtner and Rousseau 1975) and

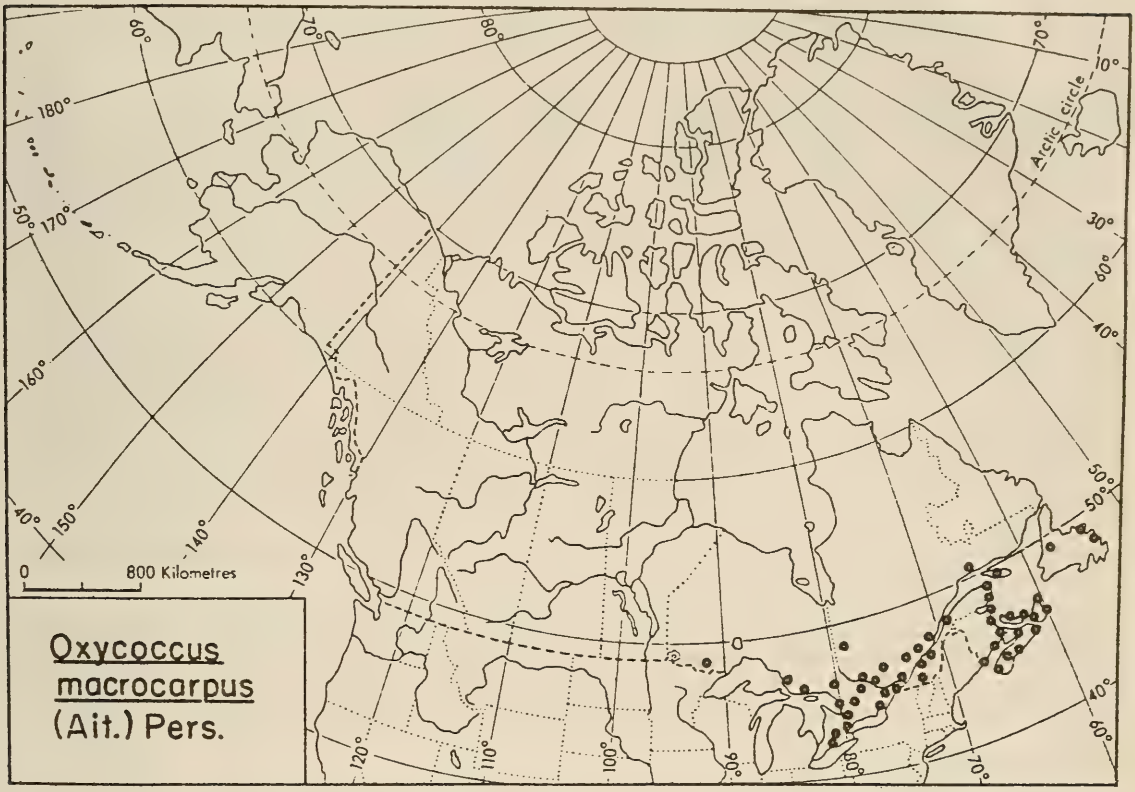

FIGURE 2. Canadian distribution of native *Oxycoccus macrocarpus* (Ait.) Pers. from specimens in the herbaria of Canada Agriculture, Ottawa, Ontario (DAO) and National Herbarium, National Museum of Canada, Ottawa, Ontario (CAN).

Quebec (Rouleau 1964). Scoggan (1957) states that *O. macrocarpus* has been reported from Manitoba but we have seen no specimens from that province.

The largest commercial plantings of cranberries in Canada occur in British Columbia on Lulu Island. Smaller plantings occur in Nova Scotia, Quebec and Ontario.

(b) *Altitudinal range:* In Eastern Canada this species, unlike *O. microcarpus*, is found only at low elevations, often along the seacoast. Fernald (1902) states that it disappears in the higher elevations of northwestern Maine. Ogle (1983) reports that its distribution in the southeastern United States is limited to certain parts of the Allegheny Mountains where the average elevation in West Virginia is 820 m, Virginia 773 m and Tennessee 707 m.

4. *Physical Habitat*

(a) *Climatic relations:* The fact that *O. macrocarpus* is found in the Atlantic Provinces and the southern portions of Quebec and Ontario only at low elevations suggests that it is far less tolerant of extreme cold than the closely related *O. microcarpus*. The latter species extends from eastern Labrador, around the southern shores of Hudson Bay, across the Northwest Territories to most of Alaska (Porsild and Cody 1980).

In commercial bogs where the microtopography is uneven and plants protrude above the level of the winter-ice, desiccation and severe winter killing can occur. Cross (1975) states that a combination of factors is necessary for this type of injury including frozen soil in the rhizosphere, persistent cold (−12° C) during both day and night for about a week, and wind of moderate velocity.

The cranberry plant is much more tolerant of cold in the early part of its dormant period than in the later stages. Doughty and Dodge (1966) showed that a temperature of −3° C caused only 10% injury to flower buds

under field conditions in Washington on 26 February whereas 38% were injured on 30 March by the same temperature.

(b) *Physiographic relations:* Martin (1959) stated that cranberry bogs in Island Beach State Park in New Jersey were at an elevation about a meter above sea level. Chandler and Hyland (1941) reported that in Maine *O. macrocarpus* was found mainly in sphagnum bogs, along stream banks and in marshes. Roland and Smith (1969) reported *O. macrocarpus* in similar habitats in Nova Scotia, and also in meadows inundated by spring tides and along the edge of salt marshes. In the area near Richibucto, New Brunswick, we found this species in poorly drained areas behind the sandy beaches or in peat bogs with high accumulation of organic matter. On the Magdalen Islands, Quebec, Lamoureux and Grandtner (1977) found cranberries growing at the edge or in ponds behind the coastal dunes. Rigg (1940) lists this species as common in Atlantic coast bogs.

(c) *Nutrient and water relations:* A detailed study of the nutrients found in cranberry leaves and the physical characteristics of the soils from a commercial cranberry bog in the Annapolis Valley of Nova Scotia was reported by Townsend and Hall (1971). Foliar nutrient levels (expressed as per cent dry weight) for the respective elements were: N (1.25–1.59), P (0.12–0.17), K (0.38–0.73), Ca (0.70–1.21), and Mg (0.22–0.24). Mn was relatively high (Gerloff et al. 1964) (305–908 ppm) while Fe was near normal at 75–122 ppm. Soil at all three sites was strongly acidic (pH 4.2–4.6), with low organic matter content (1.6–2.0%). Base saturation was low with exchangeable Ca at 0.64–0.98, Mg 0.11–0.22 and K 0.07–0.10 meq/100 g. The cation exchange capacity varied from 3.8 to 4.4 meq/100 g. The soil texture analysis showed a high content of sand (up to 93%), low silt (2.8%), and clay (4.2%).

Cross (1969) stated that seasons having 5 cm but not in excess of 10 cm of rainfall per month have produced good crops of cranberries.

Comeau and Beil (1984) recognized seven moisture levels ranging from hydric to submesic in a study of raised bogs on the Cape Breton Plateau. The hydric (wettest) habitat was dominated by *Nuphar variegatum* (Yellow Pond-lily). The next level of decreasing moisture was characterized by *Eriophorum angustifolium* (Cotton-grass) in which *O. macrocarpus* had a sporadic occurrence. The highest frequency of *O. macrocarpus* was in the next level (hygric) characterized by *Rhynchospora alba* (Beak-rush) and *Drosera intermedia* (Sundew).

5. *Plant Communities*

The species associated with *O. macrocarpus* in six plant communities are given in Table 1. A careful review of the phytosociological literature, e.g., Blouin and Grandtner (1971), Curtis (1959) and Maycock and Curtis (1960), failed to reveal any major reference to *O. macrocarpus*, suggesting that this species is quite rare in the St. Lawrence-Great Lakes Region and confined to a narrow range of habitats within its natural botanical range. *O. macrocarpus* was found in northern bog communities of Wisconsin where it occurred in 77% of the areas sampled (Larsen 1982) and in *Chamaedaphne* bogs of northern lower Michigan where it was the dominant species (Gates 1942). Bouchard et al. (1978) suggest that *O. macrocarpus* is a component of the eastern deciduous forest, and its occurrence on the coastal plain of St. Barbe South District in Newfoundland represents the northern limit of its distribution. This is supported by the fact that it is uncommon in sedge meadows, tidal flats and around bog sands on the coastal plain of the Gros Morne National Park in western Newfoundland (Bouchard and Hay 1976). On the east coast it appears to be more plentiful and is found in wet bog communities with *Rhynchospora alba* (Beak-rush), *Odontoschisma sphagni, Sphagnum tenellum* (Peat-moss), *S. pulchrum, S. cuspidatum, Cladopodiella fluitans* and *Utricularia cornuta* (Bladderwort) (Wells 1981). In ponds on the lee side of dunes of the Magdalen Islands *O. macrocarpus* was the dominant species (Lamoureux and Grandtner 1977; Géhu and Grandtner 1982). Martin (1959) stated that the typical New Jersey cranberry bog consists of *O. macrocarpus, Sphagnum* sp., *Lycopodium inundatum* (Club-moss), *Drosera filiformis* (Dew-thread), *D. rotundifolia* (Round-leaved Sundew) and *Juncus effusus* (Soft-rush). Harshberger (1916) also reported that *O. macrocarpus* was a typical component of the ground cover of cedar and deciduous swamps in New Jersey. In West Virginia, *O. macrocarpus* forms part of the *Carex-Sphagnum* community of Cranberry Glades at an elevation of 1036 m (Darlington 1943). The main sedge species was *Carex rostrata* with lesser amounts of *C. trisperma, C. scirpoides* and *C. lurida*. The main *Sphagnum* species were *S. capillaceum* and *S. palustre*, and other vascular species were *Rubus hispidus* (Trailing Blackberry), *O. macrocarpus* (Large Cranberry) and *O. microcarpus* (Small Cranberry).

6. *Growth and Development*

(a) *Morphology:* The first stage of seedling development is characterized by the development of a radicle which becomes a tap root, and by expansion of the two cotyledonary leaves at the opposite end of the axis. The apical

TABLE 1. *Oxycoccus macrocarpus* (Ait.) Pers. and associated species in plant communities.

Site[1]	I	II	III	IV	V		VI
Lat.	44° N	47° N	46–49° N	44–47° N	39° N		39–40° N
Long.	65° W	62° W	53–56° W	87–93° W	74° W		74–76° W
Altitude (m)	1	5	varied	varied	5		varied
Shrubs and Herbs	C%[2]	C%	C%	F%[2]	C%	F%	F%
Acer rubrum					1	5	
Alnus rugosa							12
Amelanchier canadensis					—	1	25
Ammophila breviligulata					1	8	
Andromeda glaucophylla				94			
Andropogon glomeratus							6
Aralia nudicaulis							18
Aronia arbutifolia							6
Aspidium simulatum							6
Aster nemoralis							6
Baccharis halimifolia					4	9	
Bartonia paniculata							18
Cakile edentula					—	2	
Calla palustris				47			
Campanula aparinoides							6
Carex emoryi							6
C. folliculata							6
C. howei							12
C. incomperta							6
C. littoralis							18
C. stellulata							6
C. striata							6
C. strictior							6
C. subulata							31
C. trisperma				53			12
Chamaedaphne calyculata				88			25
Clethra alnifolia					—	2	93
Cornus canadensis				53			
Cypripedium acaule				47			
Decodon verticillatus							18
Dioscorea villosa							12
Drosera longifolia							6
D. rotundifolia				53			18
Dryopteris cristata				47			
D. thelypteris					5	21	
Eleocharis tuberculosa						6	
Eriophorum virginicum						12	
E. spissum				35			
Gaultheria hispidula				47			
G. procumbens				41			6
Gaylussacia baccata							12
G. dumosa							12
G. frondosa							68
Hibiscus palustris					1	7	
Hypericum boreale	1						
H. densiflorum							6
H. virginicum					1	6	
Hudsonia tomentosa					4	9	
Ilex glabra							12
I. laevigata							6
I. opaea					3	5	
Iris versicolor				47			
Juncus canadensis					3	12	6

TABLE 1. *Oxycoccus macrocarpus* (Ait.) Pers. and associated species in plant communities (*continued*).

Site[1]	I	II	III	IV	V		VI
Lat.	44° N	47° N	46–49° N	44–47° N	39° N		39–40° N
Long.	65° W	62° W	53–56° W	87–93° W	74° W		74–76° W
Altitude (m)	1	5	varied	varied	5		varied
	C%[2]	C%	C%	F%[2]	C%	F%	F%
J. effusus	12						
J. sp.		trace–50					
Juniperus virginiana					2	11	
Kalmia angustifolia							37
K. latifolia							25
K. polifolia				82			
Ledum groenlandicum				77			
Leiophyllum buxifolium							6
Leucothoe racemosa							62
Lindera benzoin							18
Lycopodium inundatum							6
Lycopus uniflorus	2						
Lyonia ligustrina							37
L. mariana							25
Menyanthes trifoliata				41			
Mitchella repens							12
Myrica gale	1	trace–25					
M. pensylvanica					3	14	6
Muhlenbergia uniflora							6
Onoclea sensibilis	3						
Orontium aquaticum							12
Osmunda cinnamomea					1	2	50
O. regalis					—	1	
Oxycoccus macrocarpus	69	trace–50	trace–5	77	—	1	37
O. microcarpus				65			
Panicum verrucosum							6
Parthenocissus quinquefolia					2	9	12
Peltandra virginica							6
Phragmites communis					—	5	
Pogonia ophioglossoides							6
Polygala brevifolia							12
Polygonum pensylvanicum					3	6	
Potentilla anserina	1						
P. palustris				47			
Prunus serotina					3	7	
Quercus ilicifolia							6
Rhexia virginica							6
Rhododendron viscosum							81
Rhus radicans					12	59	31
R. vernix							37
Rhynchospora alba		trace–50					12
Rosa rugosa					6	22	
Rubus hispidus							18
Sabatia lanceolata							6
Sarracenia purpurea				77			12
Schizaea pusilla							6
Scirpus americanus					1	8	
Smilacina trifolia				77			
Smilax glauca							25
S. rotundifolia					11	35	43
Solidago sempervirens					—	3	
S. tenuifolia							6
Spiraea latifolia	6						

TABLE 1. *Oxycoccus macrocarpus* (Ait.) Pers. and associated species in plant communities (*concluded*).

Site[1]	I	II	III	IV	V		VI
Lat.	44° N	47° N	46–49° N	44–47° N	39° N		39–40° N
Long.	65° W	62° W	53–56° W	87–93° W	74° W		74–76° W
Altitude (m)	1	5	varied	varied	5		varied
Shrubs and Herbs	C%[2]	C%	C%	F%[2]	C%	F%	F%
Trientalis borealis							12
Typha latifolia					4	9	
Utricularia cornuta			trace–5				
Vaccinium angustifolium				59			
V. atrococcum							37
V. corymbosum					2	3	81
V. myrtilloides				59			
V. pallidum							56
Viburnum nudum							6
Woodwardia areolata				25			
W. virginica				43			
Mosses							
Aulacomnium palustre							43
Calliergonella schreberi	1						
Cladopodiella fluitans			trace–5				
Dicranum flagellare							68
D. scoparium							43
Hypnum imponens							25
Leucobryum glaucum							62
Leucodon julaceus							6
Odontoschisma sphagni			trace–5				
Plagiothecium micans							43
Polytrichum commune							6
P. ohioense							12
Sphagnum compactum							18
S. cuspidatum			trace–50				6
S. magellanicum							75
S. pulchrum			trace–50				
S. recurvum							68
S. tenellum			5–100				
S. sp.	1				5	10	
Tetraphis pellucida							18
Thelia hirtella							6
Thuidium delicatulum							18

[1]Original — II — Géhu and Grandtner (1982), III — Wells (1981), IV — Larsen (1982), V — Martin (1959), VI — Little (1951).
[2]C% — percent cover, F% — percent frequency.
Nomenclature follows original authors except for *Oxycoccus macrocarpus* and *O. microcarpus*.

shoot grows out shortly thereafter bearing the true leaves. Lateral buds on the main stem develop into shoots which spread as slender stolons which allow this species to rapidly colonize an area. The stolons produce vertical shoots at the leaf nodes and these bear flowers and fruits (Figure 1C).

(b) *Physiology:* A growth chamber study was set up with 5 plants of 5 cultivars in 3 chambers each having a different temperature regime, but having a constant 16h light/8h dark photoperiod and a constant light intensity of 6800 lux. Plants had been propagated from a single 20 cm stem, grown for one season in the greenhouse and for two months outdoors prior to being placed in the chambers. After 57 days all current vegetative shoot growth of each plant was measured. For the range of temperatures studied (16 to 26° C), growth increased with increasing temperature (Table 2). The differences in growth for the cultivar Pilgrim after 25 days are seen in Figure 3.

The physiology of developing and maturing fruit has received considerable attention. A very active period of respiration and ethylene production occurred at the time of fertilization and this was followed by a gradual

TABLE 2. Total shoot length (cm) of five *Oxycoccus macrocarpus* cultivars grown in a 16-h photoperiod at three temperature regimes in growth chambers at the Kentville Research Station. Light intensity in each chamber was 6800 lux and there were five plants of each cultivar grown from a 20 cm cutting in each chamber. Shoot length was recorded after 57 days.

Cultivar	Regime #1 11°C in dark 16°C in light (mean ± SE)	Regime #2 16°C in dark 21°C in light (mean ± SE)	Regime #3 21°C in dark 26°C in light (mean ± SE)
Black Veil	47.8 ± 0.9	267.9 ± 20.6	455.8 ± 60.1
Pilgrim	64.0 ± 16.2	511.2 ± 86.3	887.1 ± 53.9
CN	239.9 ± 34.1	710.5 ± 44.9	1017.3 ± 50.4
Crowley	152.3 ± 19.3	821.7 ± 72.4	1003.7 ± 62.4
Bergman	92.5 ± 17.7	613.1 ± 65.4	1186.1 ± 85.4

decline until the last week of August, when a marked increase in ethylene occurred (Forsyth and Hall 1969). A dramatic change in rate of respiration just prior to harvest was reported by Forsyth and Hall (1967b). Outward diffusion of CO_2 from native seedling cranberries proceeded at a rate of 2.56 cm^{-2}–hr^{-1} and the movement of O_2 into the same was 3.28 cm^{-2}–hr^{-1} (Forsyth et al. 1973).

Hall and Stark (1972) showed that anthocyanin formation in both leaves and fruit was enhanced by decreasing temperature.

Rates of photosynthesis were shown by Forsyth and Hall (1967a) to be temperature dependent; however, a low but measurable rate, greater than the rate of respiration, was found even at temperatures as low as 3.5°C. This was considered an important factor in preventing oxygen deficiency under the ice during the winter months. Heavy snowfall in winter can reduce light penetration through the ice and prevent photosynthesis by the evergreen leaves. When the oxygen content of the water around submersed leaves falls below 6 ppm, the previous season's leaves drop, fruit set is impaired and shoot apical meristems are severely injured (Bergman

FIGURE 3. Growth of the cranberry cultivar Pilgrim at three temperature regimes in a 16 h photoperiod: A. 11°C dark 16°C light, B. 16°C dark 21°C light and C. 21°C dark and 26°C light. Plants placed in growth chambers on 23 November 1981 and photographed on 8 December 1981. Light intensity was 6800 lux.

1948). Forsyth and Hall (1975) investigated the reason for low yields on a cranberry bog in Nova Scotia and found oxygen levels in the water surrounding the cranberry leaves in February as low as 4 ppm. In a laboratory study in which shoots of intact plants were placed in a plexiglass chamber with inside temperature of 25° C, Bonn et al. (1969) found that rates of assimilation occurring in young leaves of *O. macrocarpus* were 40.0 mg CO_2 dm^{-2}–hr^{-1} compared with 14.4 in *Vaccinium angustifolium* leaves.
(c) *Phenology:* Hicks et al. (1968) reported the dates of the various stages of phenological development of *O. macrocarpus* at Aylesford, Kings County, Nova Scotia as: (1) March 8 — dormant shoots, (2) May 13 — terminal buds beginning to swell, (3) June 24 — florets visible, (4) July 12 — full bloom, (5) August 2 — green berries developing, (6) August 19 — berries showing first flush of color, and (7) September 1 — berries nearing maturity. In the wild, seeds germinate after the resumption of growth in the spring. Flower buds for next year's flowers develop in late August in Wisconsin (Goff 1901) and slightly later in Nova Scotia (Bell and Burchill 1955). These latter authors also showed that the primordia of the pistil and stamens are merely fluted rings of meristematic tissue at the beginning of winter dormancy. Root growth is governed by temperature and water levels in the soil (Hall 1971).

7. *Reproduction*

(a) *Floral biology:* Roberts and Struckmeyer (1942) studied the reproductive organs of *O. macrocarpus* and showed that the pollen grains were in tetrads with each grain capable of developing a pollen tube; they implied that pollination was either by wind or bees. Tomlinson (1969) reviewed the evidence for wind pollination and presented data showing that few or no berries were set where bees were excluded from the plants. Production was greatly increased when honeybees were introduced into bogs. Tomlinson further stated that the pistil was not pollinated by pollen from stamens of the same flower because the pistil was not receptive until about a day after the pollen had been shed. Rigby et al. (1972) emphasized the value of wild bees and verified that berry set and fruit size were much reduced in areas where honeybees were excluded. Marucci and Filmer (1964) reported that fruit set appeared greater on portions of bogs in New Jersey where two cultivars were planted side by side. Dr. M. N. Dana of the University of Wisconsin presented data at a meeting of cranberry workers in Massachusetts in September 1982 which showed that cultivars which were selfed set as large and as many berries as those that were cross-pollinated with pollen of another cultivar. Free (1970) stated that a fruit set in excess of 50 per cent is difficult to attain.

(b) *Seed production and dispersal:* Rigby and Dana (1971) studied the berry size and seed production of five cultivars. The average seed number per fruit varied from 8.3 to 13.2 with a maximum of 37. The percentage of seedless berries ranged from 0.4 to 5.5. Hall and Aalders (1965) found a positive correlation ($r = + 0.757$) between seed number and berry weight.

The chief non-human consumers of cranberry fruit are *Ondatra zibethica* (Muskrat) and *Odocoileus virginianus* (White-tailed Deer), but the seeds are dispersed mainly by water, a few shorebirds and gamebirds (see Section 9(c)).

(c) *Seed viability and germination:* Demoranville (1974) found that cranberry seeds from the cultivar Early Black germinated 99% at 26.5° C by day 13, 99% at 21° C by day 16 and 75% at 16.5° C by day 35. Demoranville also reported that a mixture of 80% sand and 20% peat was the most satisfactory germination medium from the standpoint of cost, ease of handling and prevention of damping off. Devlin and Karczmarczyk (1974) stated that cranberry seeds were dormant at the time of harvest regardless of temperature and moisture. They obtained a maximum germination of 97% after seeds were subjected to 8 days of light followed by 12 days in the dark. Shorter periods of exposure to light gave poorer germination, whereas 20 days of dark gave only 1% germination. Devlin and Karczmarczyk (1975) reported that gibberellic acid promoted germination, but the seed coat prevented gibberellic acid entry unless the seeds were scarified. Further studies by Devlin and Karczmarczyk (1977) showed that gibberellic acid stimulated germination and abscissic acid inhibited germination of cranberry seeds. Kinetin induced some germination but was less active than gibberellic acid. Devlin et al. (1976) found that germination of nondormant cranberry seeds was inhibited by exogenous abscissic acid. Extracts of dormant seeds, which contained high amounts of abscissic acid, inhibited germination, whereas those from nondormant seeds did not. Greidanus et al. (1971) germinated cranberry seeds under greenhouse temperatures with winter daylength at Madison, Wisconsin and found that *Sphagnum* moss gave results equivalent to perlite, silica sand or vermiculite, but superior to sterilized soil. Stone (1982) reported similar findings with no significant difference in germination on sand, sphagnum peat, and 1:1 mixture of sand-peat.

(d) *Vegetative reproduction:* Hall (1970) found that stolons buried in sand had significantly more growth than

those placed on the surface of the sand; he also grew plants in pots and trained the stolons in three positions: vertical, oblique and horizontal. Vegetative growth of the stolons expressed as a ratio of stolon length/side branch length was vertical 2.15, oblique 1.68 and horizontal 0.92.

The pattern of lateral growth of *O. macrocarpus* is similar to that reported for *V. myrtilloides* (Vander Kloet and Hall 1981). However the amount of growth in any given period by *O. macrocarpus* exceeds by several times that of *V. myrtilloides*.

8. *Population Structure and Dynamics*

(a) *Age distribution:* Although the stolons increase slightly in diameter from the distal to proximal part of the seedling, we found no evidence of distinct growth rings as reported in *V. angustifolium* and *V. myrtilloides* (Hall 1957). Age of one plant excavated at Auburn, Kings County, Nova Scotia was estimated at 8 yrs based on the previous year's growth relative to total growth. Undoubtedly other plants in the mass of stolons were older.

(b) *Size distribution:* As *O. macrocarpus* grows larger the apical dominance of the first stolon is lost and lateral buds develop into a mat of intertwining stems. Sixteen plants of *O. macrocarpus* collected on 25 May 1984 were measured for greatest mat diameter and total stolon growth. The largest had a diameter of 339 cm and stolon growth of 649 cm while the smallest had a diameter of 35 cm and stolon growth of 49 cm.

(c) *Growth and turnover rates:* A violent storm, such as a hurricane, which could easily change an existing tidal marsh or bog is one of the few possibilities for opening a new habitat favorable for *O. macrocarpus* establishment. In areas where *O. macrocarpus* already exists, the addition of more sand would be beneficial in anchoring existing plants and promoting new growth. Residents of Cape Cod, Massachusetts got their initial ideas for cranberry culture by observing the phenomenon in coastal areas (Demoranville 1982).

(d) *Successional role:* A number of authors (e.g., Harshberger 1916; Larsen 1982; Ogle 1983) indicate that *O. macrocarpus* represents an edaphic climax community on sites with low soil pH, poor drainage and cool temperatures often supporting a luxuriant growth of *Sphagnum*. Nichols (1918) states that in northern Cape Breton Island cranberries (both *O. macrocarpus* and *O. microcarpus*) and sedges play an important successional function as their roots and stems bind together the partially decomposed peat moss producing a floating mat formation.

The dramatic increase in area occupied by *O. macrocarpus* in the last 200 years is largely due to man who has planted stolons in beds where competing vegetation has been removed and the water and nutrient levels of the soil have been modified to improve vegetative growth and fruiting.

9. *Interaction With Other Species*

(a) *Competition:* The main competitors of *O. macrocarpus* are grasses and sedges as well as some herbaceous and woody dicots able to grow in poorly drained areas. Cross (1952) has described in detail the important grasses that inhabit Massachusetts cranberry bogs. Dana (1964) points out that the invasion of certain species, such as *Echinochloa crusgalli* (Barnyard Grass), results from poor bog management that destroys the continuous canopy of cranberry plants which inhibit and competitively exclude other species. The recent increase of *Carex chordorrhiza* (sedge) in many Wisconsin plantings is probably related to the movement of harvesting equipment, which carries seeds and pieces of rhizomes from one property to another. Certain woody species such as *Salix* spp. (willows), *Chamaedaphne calyculata* (Leatherleaf) and *Spiraea latifolia* (Meadowsweet) compete with *O. macrocarpus* for space, water and nutrients. The relative ability of 19 marsh species to absorb Al, Mn, P and N has been shown by Small (1972). *Oxycoccus macrocarpus* was inferior to the others in its ability to accumulate N and Al, about median for P, and extremely competitive for Mn. Hicks et al. (1968) showed that a heavy canopy of *Calamagrostis canadensis* (Blue-joint), *Carex nigra* (sedge) and/or *Scirpus rubrotinctus* (Red-tinged Bulrush) greatly reduced the light intensity on a cranberry bog in Nova Scotia causing a significant reduction in the total number of cranberry shoots, number of blooming shoots, and the average number of flowers per blooming shoot. In British Columbia, *Eriophorum chamissonis* (Cotton-grass) similarly decreased the mean number of flowering uprights, flowers, berries and final yield by about 30% (Yas and Eaton 1982). The number of vegetative uprights was also decreased by 14%.

(b) *Symbiosis:* Work in New Jersey (Marucci 1966) and Wisconsin (Farrar and Bain 1947) indicated that cranberry fruit set is pollinator-limited; wild insect pollinators were few in number on commercial plantings, and the addition of at least one colony of bees per acre greatly enhanced the yield. Franklin (1950) stated that most of the bumblebees visiting cranberry flowers in Massachusetts come from nests in adjoining woodlands and that the most abundant one is *Pratobombus bimaculatus*. According to Franklin, bumblebees pollinate

under more adverse conditions, earlier and later in the day, and more rapidly than honeybees. For example, honeybees pollinated 8.8 flowers per minute whereas *Bombus affinis* did 16.6, *B. terricola* 11.8, and *Pratobombus bimaculatus* 10.9. Bumblebees were also more effective in fruit set (56%) compared with honeybees (43%). Hand pollination in the same experiment gave 69% fruit set.

Addoms and Mounce (1931) reported that growth of *O. macrocarpus* in cultures with pH 4.9 to 5.6 where the N source was in the ammonium form grew better than those with a nitrate source; cultures lacking N but supplied with the endophytic fungus *Phoma radicis* made little growth. Bain (1937) reported four fungi forming mycorrhizal associations with cranberry seedlings; however, none of the fungi was of the *Phoma* type. More recent reports by Pearson and Read (1973a, 1973b) have shown that a mycorrhizal association exists and that carbon is transported from the plant to the fungus and phosphorus from the fungus to the plant.

(c) *Predation and parasitism:* Martin et al. (1961) stated that few birds other than some marsh and shorebirds, and in the Lake States Area upland gamebirds such as *Tympanuchus phasianellus* (Sharp-tailed Grouse), feed on the fruit. Grange (1948) discusses the fruits eaten by grouse and says that the cranberry is available during the fall, winter and spring, has a heavy degree of usage, and he ranks it eighth in importance of some ten native fruits.

Dr. A. J. Erskine (Migratory Birds, Atlantic Region, Canadian Wildlife Service) stated that he was not aware of any major use of *O. macrocarpus* by birds or mammals; Dr. Donald G. Dodds (Biology Department, Acadia University, Nova Scotia) has been involved with food habits and feeding ecology studies of several primary consumers including moose, deer, hare, muskrat and grouse and has not found this species to be important to any of them.

A complete listing of the insects, their life histories, the stage attacking various parts of the cranberry plant, and means of control are given in the monographs of Franklin (1950, 1952). The cranberry fruitworm (*Acrobasis vaccinii*) is the most serious insect pest of the large cranberry in the Maritime Provinces and Quebec. The eggs are laid within the calyx cup and the larva enters the berry near the stem end to feed on its pulp. Several species of fireworm may cause damage to cranberries but the Blackheaded Fireworm, *Rhopobota naevana*, is the most common. Larvae web together three to four terminal leaves and feed on them. Two other insects which may be troublesome are the Cranberry Girdler, *Crysoteuchia topiaria*, the larvae of which feed on the bark in September, and the Cranberry Tipworm, *Dasyneura vaccinii*, the larvae of which feed on the young terminal buds in the spring (Hall et al. 1981).

Fungi reported on cranberry plants in Canada up to 1967 are listed by Conners (1967). Gourley and Harrison (1969) reported that most of the rot occurring in cranberry fruit in Nova Scotia developed in storage. At that time, end rot caused by *Godronia cassandrae* f. *vaccinii* was the most serious. Gourley (1979) reported 20 additional fungi occurring on the fruit. In this later study, *Sporonema oxycocci* was the principal fungus occurring on leaves and causing fruit rot.

(d) *Toxicity and allelopathy:* Devlin (1980) found that wheat seeds placed on moist vermiculite were inhibited in root and shoot growth by 1 ml of an extract from cranberry leaves and that 5 and 10 ml of the same solution markedly reduced seed germination.

10. *Evolution and Migration*

A study of the origin and early development of the genus *Oxycoccus* (as subgenus of *Vaccinium*) has been published by Galletta (1975). *Oxycoccus* is characterized as a vine-like, prostrate, spreading plant as opposed to the subgenus *Hugeria* with flowers borne on upright shoots. The flowers are deeply cleft as opposed to the bell-shaped corolla in section *Vitis-idaea*, and the flowers occur singly as in the bilberries (Fernald's *Euvaccinium*). Camp (1944) considered that *O. macrocarpus* was the most primitive species of the subgenus and had a southern origin; his conclusion was based on the fact that *O. macrocarpus* has a primitive inflorescence, a diploid chromosome number, and the species most closely resembling it in flower structure is *V. erythrocarpum* (Mountain Cranberry), which occurs in the southern Appalachians. Shultz (1944) maintained that the subgenus should be left within the genus *Vaccinium* because (1) it was intermediate between such species as *V. uliginosum* (Alpine Bilberry) and *V. erythrocarpum* and (2) it had been hybridized with *V. vitis-idaea* and *V. ovatum*. Vander Kloet (1983) studied *Oxycoccus*, relegated it to *Vaccinium* section *Oxycoccus*, and concluded that there were just two species, *V. macrocarpon* and *V. oxycoccos*; the former has narrowly elliptic leaves and the latter has ovate leaves. *V. macrocarpon* leaves are usually $\geqq$ 1 cm long while those of *V. oxycoccos* are $\lesssim$ 1 cm and the margins revolute. Finally the pedicels of *V. macrocarpon* had leaf-like bracts, whereas *V. oxycoccos* had scale-like bracts which were sometimes absent, and, if present, were red in color.

11. *Response Behavior*

(a) *Fire:* Beckwith (1931) stated that many cranberry bogs in New Jersey are located in forest areas and subject to fire. Portions of the cranberry plant directly exposed to fire are consumed and heat in excess of 60° C will kill even the more woody ericoids in the area affected (Flinn and Pringle 1983). New growth arises under favorable conditions from lateral dormant buds about 3 cm behind the margin of the dead tissue. Under dry conditions cranberry plants are quite combustible.

(b) *Grazing and harvesting:* Near Arichat, Nova Scotia, a grower found it necessary to build a picket fence on the wooded side of his bog to prevent deer from entering and feeding on the cranberry plants. Horizontally trailing stems pulled from the soil by the deer die from desiccation under warm dry conditions. Upright shoots that are cut off by the deer regenerate new shoots from dormant lateral buds below the cut. Damage is most severe in the spring when deer remove the terminal flower buds and thus prevent flowering and fruiting.

When harvesting is done by handpicking the injury to the plant is minimal, consisting of the loss of a few leaves due to trampling. However with the raking or beating effect of mechanical harvesters loss of foliage and shoots is substantial and many of the horizontally trailing stems are uprooted. Commercial cranberry bogs are intentionally flooded for a week following harvesting to rid the bog surface of leaves, and other debris, and also to allow the plants to establish new root systems (Franklin 1948).

(c) *Flooding:* During the dormant season cranberry plants are quite tolerant of flooding and formerly late holding of water was an accepted cultural practice (Beckwith 1940). In New Jersey, Wakabayashi (1925) found that the plants were most susceptible to injury in the late bloom period and any submersion longer than 24 h suffocated the flowers and developing fruit. More recent work indicates that once flowering begins, flooding longer than overnight will result in wilting of new growth and reduced fruit set (Cross 1982) [see also 6 (b)].

(d) *Drought:* Chandler (1951) observed that most of the roots of cranberry were near the soil surface and, due to the high sand fraction of most cranberry soils, injury from desiccation occurred in a relatively short period. Crowley (1954) stated that bogs suffering from a lack of moisture rarely produced a good crop and lack of flower bud formation severely reduced the crop of the following year.

(e) *Herbicides:* Herbicides are used in commercial cranberry bogs to eliminate weeds which compete with the cranberry plant. Peterson et al. (1968) reported that the principal herbicides used in Massachusetts in 1966 were Dichlobenil followed by much lesser use of Chlorpropham, Dalapon, Simazine and Naptalam. More recently Norflurazon and Napropamide have been recommended for controlling several grasses and sedges in newly planted bogs (Demoranville and Devlin 1982). All of the above mentioned herbicides are relatively non-toxic to cranberry plants. 2,4-D and 2,4,5-T are only recommended for brush control on dikes surrounding cranberry bogs. Cranberry plants are highly sensitive to these latter materials, showing systemic as well as localized dying of tissue. Glyphosate, which inhibits protein synthesis, is very toxic to cranberries but is occasionally used to kill woody weeds with a wick applicator.

(f) *Chemical changes:* Common salt (sodium chloride) has been recommended for the control of *Osmunda regalis* (Royal Fern), *O. cinnamomea* (Cinnamon Fern) and *Apios americana* (Wild Bean) on cranberry bogs (Demoranville and Devlin 1982). Cranberry plants are quite tolerant of salt spray due to the waxy nature of the upper surface of the leaf. However, bogs inundated with sea water following the passage of hurricanes have been damaged (Chandler and Demoranville 1959a). Injury was most severe on recently harvested bogs where the root system had been disturbed and on newly planted clones with limited root systems.

If applied in excess to cranberry stands, nitrogen results in excessive stem growth. Sometimes in commercial culture this unwanted growth must be partially removed by pruning.

(g) *Frost:* Cranberry bogs are subject to frost because of (1) cold air drainage from surrounding uplands, and (2) slow heat conduction from the organic soil (Bates 1971). The application of 1 to 3 cm of fresh sand lessens frost injury. Demoranville (1982) stated that the temperature of shoot tips on a recently sanded area was 1° C higher in late spring due to better heat reflection than on a stand with considerable organic litter. Peterson et al. (1968) state that buds in early April will tolerate below freezing temperatures, but towards the end of April, as they begin to expand, they are prone to injury at temperatures below -6.5° C and must be protected with sprinkler irrigation. Curtis (1959) stated that cranberry bogs in Wisconsin are subject to light frost during the summer months.

12. *Relationship to Man*

The Indians of New England called the cranberry "sasemineash" (Hedrick 1919). The usage of cranberries as a food by native people in Canada was outlined by Arnason et al. (1981).

Many people seek out natural stands of cranberries in the fall to pick the dark, tartly acid red berries. They are commonly used in making jelly, sauce and pie or as whole berries in various festive breads and muffins (Buszek 1977). Today more than 50% of the crop from commercial plantings is used to produce juice, either alone or in combination with other juices such as grape, apple or prune. Two distinctive characteristics of cranberry fruit are the high pectin and benzoic acid content. The two most widely grown cultivars in Massachusetts, Early Black and Howes, have a pectin content of 1.21 and 1.15% and benzoic acid content of 0.079 and 0.098%, respectively (Fellers and Esselen 1955). Cranberries are grown in beds about 1 hectare in area with a dyke around the edge which is used to service the planting (Dana and Klingbeil 1966). The plants are protected from frost during the entire growing season with sprinkler irrigation systems (Norton 1975). Berries are harvested mostly by beating the vines in water, allowing the berries to float to the surface of the water, and collecting them by suction (Norton 1975). The characteristics of the older cultivars grown in North America are given by Chandler and Demoranville (1959b) and the newer ones by Hall (1981). In Canada, cranberry growing is widely dispersed with small plantings in Nova Scotia, Quebec and Ontario (Hall et al. 1981). Some of the most productive stands in North America, yielding in excess of 20 000 kg/ha per year, are located on Lulu Island at the mouth of the Fraser River in British Columbia. Attempts have been made to grow cranberries abroad, especially in Scotland, The Netherlands, Germany (Liebster 1971) and Japan (C.E. Cross, personal communication).

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Notes

Food Habits and Average Weights of a Fall-Winter Sample of Eastern Coyotes, *Canis latrans*

GARY C. MOORE[1] and JOHN S. MILLAR[2]

Department of Zoology, University of Western Ontario, London, Ontario N6A 5B7
[1]Present address: 108 Westview St., Fredericton, New Brunswick E3A 1W9
[2]Reprint requests to be forwarded to John S. Millar

Moore, Gary C., and John S. Millar. 1986. Food habits and average weights of a fall-winter sample of eastern Coyotes, *Canis latrans*. Canadian Field-Naturalist 100(1): 105–106.

Analysis of stomach contents of a sample of Coyotes (*Canis latrans*) from New Brunswick and Nova Scotia suggests an opportunistic feeding behavior and unspecialized diet. Average weights are comparable to other samples of eastern Coyotes but are consistently higher than those reported for western Coyotes.

Key Words: Food habits, average weight, Coyote, *Canis latrans*, New Brunswick, Nova Scotia.

Between 1958 and 1973 there were occasional reports of Coyotes (*Canis latrans*) in New Brunswick but it wasn't until 1973 that they began to appear in appreciable numbers (D. J. Cartwright, personal communication). Coyotes were first recorded in Nova Scotia in 1977 (F. W. Scott, personal communication). Carcasses of Coyotes were obtained from fur harvesters in New Brunswick and Nova Scotia during the fall-winter (October-January) periods of 1979-1980 and 1980-1981 (Moore 1981). Because relatively little was known about these recent colonizers, stomach contents and individual body weights were recorded by the researchers. The following is a summary of these findings.

The stomach contents of 265 Coyotes (258 from New Brunswick and 7 from Nova Scotia) were examined (Table 1). Mammalian food items were identified largely on the basis of hair, using a reference collection and Adorjan and Kolenosky (1969). Table 1 illustrates the opportunistic feeding behavior and unspecialized diet of Coyotes. These observations are consistent with other studies conducted in Maine (Richens and Hugie 1974; Hilton 1976), Quebec (Bergeron and Demers 1981), Ontario (Voigt 1977), Michigan (Ozoga and Harger 1966), Alberta (Nellis and Keith 1976), New York (Hamilton 1974), Oklahoma (Litvaitis and Shaw 1980) and Arkansas (Gipson 1974). Snowshoe Hare (*Lepus americanus*) and White-tailed Deer (*Odocoileus virginianus*) appear to be staple items during the fall and winter (Table 1); however, the difficulty in distinguishing carrion from fresh kills precludes any definitive statement regarding the impact of the eastern Coyote on the deer population. The relatively high frequency of occurrence of small mammal hair is noteworthy considering the time of year when the collection took place.

Any interpretation of the importance of different prey species to the eastern Coyote based on these results must be carried out with caution because the proportions of individual food items likely vary with the season. The persistence of hair of different species within the stomach may also vary.

The average skinned weights of Coyotes collected during this study are summarized in Table 2. A regression equation, developed from 15 animals for which both skinned and unskinned weights were recorded, indicated that unskinned weight varied with skinned weight as: $Y = 0.16 + 1.18 X$ (where Y = unskinned weight, X = skinned weight and $R^2 = 0.92$). This equation was used to estimate the unskinned weight of all animals (Table 2). Juveniles were separated from adults based on incomplete closure of the canine root tip (Linhart and Knowlton 1969; Allen and Kohn 1976) and by examining cementum annuli on the canine root tip (Johnston 1975). Although there are inherent problems in comparing weight data (particularly that of juveniles) between studies conducted at different times of the year, these weights are consistently higher than those recorded for western Coyotes in Kansas (Gier 1968), Minnesota (Berg and Chesness 1978) and Texas (Meinzer and Guthery 1980). However, they are comparable to those reported from other eastern Coyote studies (Silver and Silver 1969; Richens and Hugie 1974; Hilton 1976; Lorenz 1978).

TABLE 1. The percent frequency of occurrence of items identified from the stomachs of 265 Coyotes collected during the fall and winter, 1979–1981, from New Brunswick and Nova Scotia.

Item	Percent Frequency of Occurrence (%)
Snowshoe Hare (*Lepus americanus*)	31.7
White-tailed Deer (*Odocoileus virginianus*)	24.5
Plants, grasses, leaves, seeds	20.4
Small mammals (*Sorex* spp., *Peromyscus* spp., *Microtus* spp., *Clethrionomys gapperi, Mus musculus, Microsorex hoyi*)	14.3
Non-edibles (straw, rubber, bags, tinfoil, paper, lead shot)	13.2
Large birds (chicken, turkey, grouse)	6.0
Porcupine (*Erethizon dorsatum*), Beaver (*Castor canadensis*), Raccoon (*Procyon lotor*)	4.9
Canis spp.	2.6
Carrion (maggots present)	1.9
Small birds	1.9
Apple	1.9
Known human garbage	1.5
Moose (*Alces alces*)	1.5
Feces	1.1
Sheep	1.1
Cattle	0.8

TABLE 2. Average skinned and estimated (see text) unskinned weights of Coyotes collected in New Brunswick and Nova Scotia, 1979–1981, by sex and age class.

Sex-Age Class	Skinned Weight (kg) Mean	Std. Dev.	Number	Unskinned Weight (kg)
Male-Juvenile	11.15	2.36	89	13.32
Male-Adult	13.97	2.10	50	16.64
Female-Juvenile	9.54	1.91	80	11.42
Female-Adult	12.78	1.59	23	15.24

Acknowledgments

This study was supported in part by the Natural Sciences and Engineering Research Council of Canada. The help of D. J. Cartwright, provincial furbearer biologist in New Brunswick, in the identification of hairs encountered during the analysis of stomach contents is greatly appreciated. F. W. Scott (Nova Scotia Museum) provided information regarding Coyotes in Nova Scotia. The New Brunswick Department of Natural Resources and the Nova Scotia Department of Lands and Forests aided in the collection of carcasses and provision of logistic support. The trappers of New Brunswick and Nova Scotia are thanked for their support of this project.

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The Narrow-leaved Cat-tail, *Typha angustifolia*, and the Hybrid Cat-tail, *T.* X *glauca*, Newly Reported from Saskatchewan

VERNON L. HARMS[1], and GEORGE F. LEDINGHAM[2]

[1]Fraser Herbarium, University of Saskatchewan, Saskatoon S7N 0W0
[2]Herbarium, University of Regina, Regina, Saskatchewan S4S 0A2

Harms, Vernon L., and George F. Ledingham. 1986. The Narrow-leaved Cat-tail, *Typha angustifolia*, and the hybrid cat-tail, *T.* X *glauca*, newly reported from Saskatchewan. Canadian Field-Naturalist 100(1): 107–110.

The Narrow-leaved Cat-tail, *Typha angustifolia* L., and the hybrid, *T.* X *glauca* Godron, are newly reported for Saskatchewan from Regina and Buffalo Pound Lake, and the latter also from Eyebrow Lake.

Key Words: Narrow-leaved Cat-tail, *Typha angustifolia, Typha* X *glauca*, Saskatchewan, distribution.

The Narrow-leaved Cat-tail, *Typha angustifolia* L., has been reported in North Dakota to extend northwestward to Rolette, McHenry, Ward, and McKenzie Counties (McGregor et al. 1977, p. 531), and in southeastern Manitoba from Vita, Otterburne, Agassiz Provincial Forest, and Gimli (Löve and Bernard 1959; Dugle and Copps 1972; Scoggan 1978, p. 231; Boivin 1979, p. 164). F.W. Schueler (personal correspondence), on a 1976 survey along Highway 6 in the Interlake Region of Manitoba, recorded *T. angustifolia* from near Oak Point, Eriksdale, Camper, Grahamdale, Fairford, to 66 km north of Fairford. Interestingly the latter stations extend the range of the species about 130 km north of the southern limit of the boreal forest zone. Dugle and Copps (1972) also cited a more western Manitoba collection by J. L. Parker (*no. 1403*, WIN) from "Sec. 18–26–22", a locality personally confirmed by the collector, James L. Parker (personal correspondence), as from about 7 miles (= 11 km) north-northwest of Gilbert Plains, northwest of Dauphin. *T. angustifolia* was not listed for Alberta by Moss (1959), Boivin (1979), or Packer (1983), nor has it been previously reported from Saskatchewan.

The first Saskatchewan record for the Narrow-leaved Cat-tail, *T. angustifolia*, appears to be a collection by George Ledingham, on 3 July 1978, from the southwest edge of Regina, just south of the junction of Pasqua Street and Highway (Trans-Canada) No. 1, where it occurred on the muddy margins of a large highway borrow pit with the Common Cat-tail, *Typha latifolia* L. (*no. 5877-a*, USAS & SASK; same location, on 8 August 1982, *no. 7819*, USAS).

The second known Saskatchewan locality record of the Narrow-leaved Cat-tail is a collection by Wayne Harris and Sheila Lamont, on 18 September 1983, from Buffalo Pound Lake at Nicolle Flats, where it was rare in a marsh with the Common Cat-tail (*Typha latifolia*) and bulrushes (*Scirpus acutus* Muhl. and *S. paludosus* A. Nels.) (*coll. no. 1782*, SASK). Figure 1.

At both localities, the Narrow-leaved Cat-tails were apparently hybridizing and possibly intergrading with the more numerous Common Cat-tails in the area, forming variable patches where the intermediate forms even out-numbered individuals of "good" *T. angustifolia*. The taxonomic name that is applicable to the natural hybrids between the two cat-tail species is *T.* X *glauca* Godron [synonyms: *T. latifolia* var. *elongata* Dudley; *T. angustifolia* var. *elongata* (Dudley) Wieg.]. Thus, the Hybrid Cat-tail, *T.* X *glauca*, is also reported here from the same Saskatchewan localities as *T. angustifolia*: Regina (3 July 1978, *Ledingham no. 5877*, USAS; 26 July 1979, *Ledingham no. 6287 & 6288*, USAS) and Buffalo Pound Lake (17 September 1983, *Lin Gallagher*, USAS). A collection from Eyebrow Lake in the Upper Qu'Appelle River Valley, 7 miles (= 11 km) northeast of Tugaske (1 July 1977, *D. Phillips no. 10*, USAS) also appears referrable to *T.* X *glauca*.

Such apparent hybrids and intergrading local populations have reportedly also been associated with most Manitoba stations of the Narrow-leaved Cat-tail (Löve and Bernard 1959; Dugle and Copps 1972; Scoggan 1978; Boivin 1979; and F. W. Schueler personal correspondence).

The two cat-tail species can be distinguished from each other by the characteristics listed in the comparison table (Table 1), which was compiled from various sources, but primarily Smith (1967). Some of the diagnostic characteristics can be seen in Figure 2.

Our Saskatchewan hybrid populations ("swarms") appear highly variable, including not only clear-cut intermediates, but almost every possible character combination between those of the putative parents (see Table 1), as well as other variants less obviously intermediate such as very short or double ♀ spikes. Since the latter variants have been noted elsewhere in *T. latifolia* populations where hybridization with *T. angustifolia* is not suspected, their presence alone

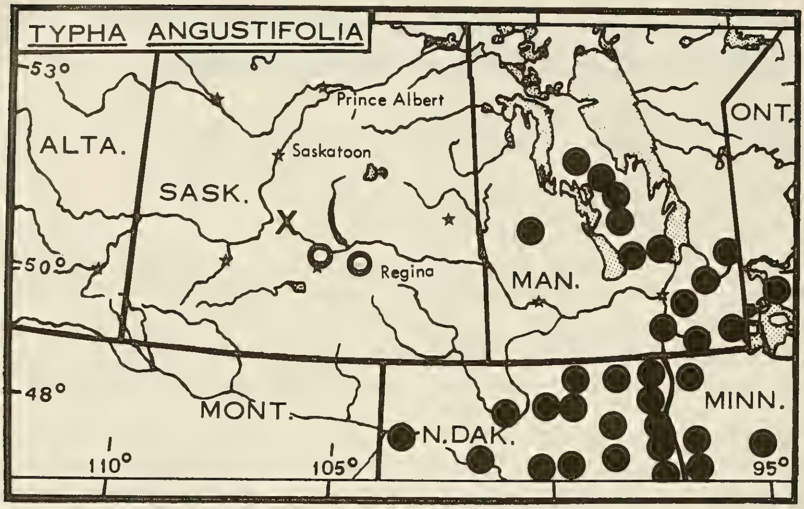

FIGURE 1. Distribution of *Typha angustifolia*. Solid circles indicate locality records of the species in neighboring provinces and states. Open circles indicate new Saskatchewan records of *T. angustifolia* and the hybrid, *T.* X *glauca*. "X" indicates new Saskatchewan records of *T.* X *glauca* alone.

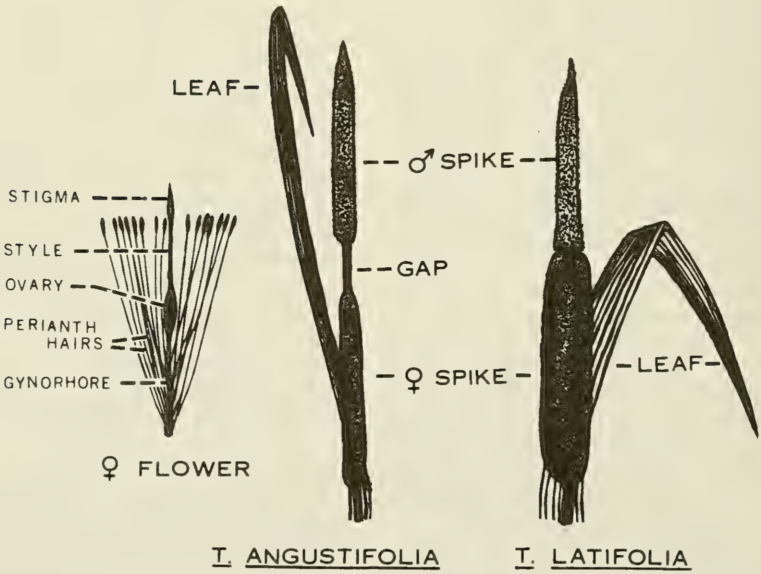

FIGURE 2. Comparison of inflorescence spikes and leaves of *Typha* species, and a ♀ flower of *T. angustifolia* enlarged.

cannot be construed as evidence of such hybridization. But there seems little doubt that their frequency is much higher than otherwise would be expected in our obviously hybrid populations. How broadly inclusive of the above variants our interpretation of the hybrid *T.* X *glauca* should be is debatable and not answerable here. But it would seem best to refer to this name only the clearly intermediate forms.

The locations of the new Saskatchewan records of *T. angustifolia* and *T.* X *glauca*, plus previous reports of *T. angustifolia* from adjacent provinces and states, are shown in the distribution map (Figure 1).

The Narrow-leaved Cat-tail is believed by some (e.g. Dugle and Copps 1972; Boivin 1979) to be currently extending its range northward and westward. Stevens (1950) reported it as "apparently . . . only recently introduced" into northwestern North Dakota, and Dugle and Copps (1972) considered it to represent an introduced species into southeastern Manitoba. Thus the newly reported Saskatchewan stations likely represent recent introductions. This cat-tail species should be looked for elsewhere in southern, east-central, and especially southeastern Saskatchewan.

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Grateful acknowledgment is given to Sheila M. Lamont and Wayne C. Harris, of Raymore, Saskatchewan, for their important contribution to this paper in having the taxonomic acumen to recognize in the field, and to realize the significance of, *Typha angustifolia* at Buffalo Pound Lake.

TABLE 1. Comparison of *Typha angustifolia* and *T. latifolia*

Typha angustifolia L. Narrow-leaved Cat-tail	*Typha latifolia* L. Common Cat-tail
♂-flowered and ♀-flowered parts of spike separated by a distinct gap over (1–) 2.5 cm wide.	♂-flowered and ♀-flowered parts of spike contiguous or with gap usually less than 1 cm wide.
Fruiting spikes more slender, less than 1.7 (–2) cm in diameter.	Fruiting spikes thicker, 1.7–3 cm in diameter.
Leaf-blades mostly less than 1 cm broad, somewhat rounded on back, quite brittle, and dark-green.	Leaf-blades (0.8–) 1–2.5 cm broad, nearly flat on back, softer (not brittle), and light-green.
♀ flower-stalks below perianth-hairs stouter, blunt, less than 0.8 mm long.	♀ flower-stalks slender, 1–2 mm long.
Pollen-grains single.	Pollen-grains in tetrads.
Leaf-sheath edges overlapping and closed at throat, at least the upper ones with ± distinct auricles.	Leaf-sheath edges spread open nearly to base, ± tapering into blade portion, usually lacking distinct auricles.
Stigmas nearly linear.	Stigmas lanceolate to lance-ovate.
Fruiting spikes dark- to reddish-brown, lacking any blackish markings.	Fruiting spikes dark-brown, often with blackish markings.
Stems more slender.	Stems mostly stouter.
Rhizomes more slender and creeping.	Rhizomes very thick and spreading.
Leaves exceeding (i.e. over-topping) spikes.	Leaves mostly equalling spikes.
Perianth-hair tips enlarged (somewhat club-shaped) and brownish.	Perianth-hair tips linear and colorless.
♂ flowers subtended by linear, often split-tipped, brownish bracteoles.	♂ flowers subtended by hair-like, non-split, colorless bracteoles.
Seeds positioned somewhat above middle of achene-fruit.	Seeds positioned at middle of achene-fruit.
Specimens that are clearly intermediate between *Typha latifolia* and *T. angustifolia* by the table may be referred to the putative hybrid taxon *T.* X *glauca*.	

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Addendum: Subsequent to the revision of this paper a third Saskatchewan locality for the Narrow-leaved Cat-tail, *Typha angustifolia* L., was discovered by George F. Ledingham at *ca.* 4 km north of Sintaluta (*ca.* 18 km east of Indian Head) 11 September 1984, *G. F. Ledingham 8906* (USAS and SASK).

Survival of Dabbling Duck Broods on Prairie Impoundments in Southeastern Alberta

DAVID C. DUNCAN

Department of Zoology, University of Alberta, Edmonton, Alberta T6G 2E9

Duncan, David. C. 1986. Survival of dabbling duck broods on prairie impoundments in southeastern Alberta. Canadian Field-Naturalist 100(1): 110–113.

Brood survival of Northern Pintails (*Anas acuta*) and Gadwalls (*Anas strepera*) was examined on prairie impoundments near Brooks, Alberta. A maximum of 4 out of 15 broods (27%) survived. It is suggested that duck brood survival is low in prairie/grassland habitats.

Key Words: Northern Pintail, *Anas acuta,* Gadwall, *Anas strepera,* brood survival, duckling, prairie, Alberta.

Brood survival rate, the proportion of broods in which at least one individual survives to fledging, has been recognized as an essential parameter in duck population dynamics (e.g., Cowardin and Johnson 1979). Studies of brood survival have shown that losses of entire broods may be considerable and consequently production estimates based solely on numbers of nests, nest success rates and brood counts may be misleading (Ball et al. 1975; Reed 1975; Ringleman and Longcore 1982; Talent et al. 1983). Dzubin and Gollop (1972: 135) concluded that brood survival was "the single most important proximate factor controlling fall population size" of Mallards (*Anas platyrhynchos*) on their grassland study area during the drought years. Nevertheless, brood survival rates and the effect of various habitat conditions upon them remain poorly documented (Cowardin and Johnson 1979). The objective of the present study was to examine brood survival of dabbling ducks on water impoundments in the mixed prairie of southeastern Alberta. Two species, Northern Pintail (*Anas acuta*) and Gadwall (*Anas strepera*), were examined in this study.

Study Area and Methods

The study was conducted in an area of grazed mixed grass prairie about 35 km south-east of Brooks, Alberta during 1981 and 1982. The study area contained two impoundments [Kininvie F (50° 22′N, 111° 30′W) and Kininvie S (50° 19′N, 111° 30′W); described by Giroux 1981] which are managed for waterfowl production by Ducks Unlimited Canada. At high water levels, Kininvie F is approximately 2.0 km^2 in area and Kininvie S is about 0.75 km^2. These basins contain artificial islands and are less than 1 m deep except for 1–2 m moats around the islands. During

both years of the study, Kininvie F retained greater than 0.5 m of water over the summer. In Kininvie S, the water level declined to about 0.5 m by midsummer of 1981 when water input refilled it to full supply level, whereas in 1982 there was no water input and by August the only open water was in the moats around the islands.

Female ducks were trapped on their nests using either a modified Weller trap (Weller 1957) or a drop trap (Sowls 1949) and were banded and outfitted with solar-powered radio transmitters (Telemetry Systems, Mequon, Wisconsin). The transmitters were fixed on the birds using a harness design similar to that described by Dwyer (1972). The transmitter and harness weighed approximately 20 g. Some pintail hens were also marked with nasal saddles. Presence of a brood was determined by direct sighting or from distraction behavior of the hen. A brood was considered to have not survived when its hen was consistently found without ducklings prior to 30 days after hatch. Telemetry checks were made every 2–3 days on average. Cases were excluded if there was any possibility that human disturbance could have caused the loss of the brood (i.e., if hens became separated from their broods while performing distraction displays and were found without ducklings on subsequent checks). Of six such instances, five occurred within three days of hatch.

Results and Discussion

It is assumed that radio-marking the hens did not significantly affect the subsequent survival of their broods. Ball et al. (1975) found that brood attrition rates were the same for radio-marked and unmarked hens. In addition, Gilmer et al. (1974) concluded that radio packages had no serious effects on a number of aspects of duck behavior. In my study, there was no evidence that radio transmitters adversely affected the brood-rearing ability of hens that continued incubating after being marked.

Survival Rate

Only two broods (both pintails) out of 13 (seven pintail and six Gadwall) survived to 30 days of age; survival to 30 days after hatch was considered indicative of survival to fledging because most mortality occurs before that age (e.g., Evans et al. 1952; Ball et al. 1975; Ringelman and Longcore 1982) and some hens may desert their broods after that time (Talent et al. 1983). Two additional broods (both Gadwalls) survived to 15 days after hatch, however, radio contact with one hen was subsequently lost and human disturbance was suspected as the cause of loss of the other brood shortly thereafter (see Methods). Thus, four out of 15 broods (27%) at most may have survived.

The brood survival rate indicated in this study is lower than that generally reported for dabbling ducks, although it is greater than or equal to rates estimated for Common Eider (*Somateria mollissima*) populations (McAloney 1973; Milne 1974; Mendenhall 1976). Ball et al. (1975), using radio telemetry, estimated brood survival of Wood Ducks (*Aix sponsa*) and Mallards in forest habitat in north-central Minnesota at 70–80%. Greater than half of their sample was derived from hens and broods that were captured within two days after hatch, and consequently their results could overestimate the actual survival rate if significant mortality occurs shortly after hatch. Talent et al. (1983) estimated Mallard brood survival in the pothole region of North Dakota at 48% using radio telemetry, and Ringelman and Longcore (1982) found that three of eight radio-marked Black Ducks (*Anas rubripes*) in Maine lost their broods. Dzubin and Gollop (1972) examined brood survival of Mallards in the grassland and aspen parkland of Saskatchewan without the use of telemetry, and estimated that the survival rate of broods in grassland (relatively similar habitat to this study) was less than 30%. Their study and the results reported here indicate that duck brood survival in prairie/grassland habitats may be low. Dzubin and Gollop (1972) found brood survival in grassland to be substantially lower than in parkland, which suggests that differing conditions in these habitats affect the success that ducks have in rearing broods. The geographical proximity of these habitats would appear to preclude weather as a direct, differential mortality factor, although the greater aridity in grasslands may be of ultimate importance. Predation or productivity (in terms of food or cover for broods) would appear to be the most likely cause of any difference in brood survival rates between these habitats. Disparity in brood survival, nest success, and population density between Mallards breeding in the grassland and parkland has led to speculation that the populations breeding in these areas may differ genetically (Dzubin and Gollop 1972; Batt and Prince 1978).

Eight of the 11 hens that lost their broods in this study did so within nine days after hatch. The time of loss of the other three broods was uncertain because the brood status of those hens was not determined until 17–25 days after their broods were hatched. High duckling mortality in the first few days after hatch has been reported in a number of other studies (Low 1945; Keith 1961; Talent et al. 1983). The early loss of five of the six broods which were excluded from the analysis due to the possibility of human disturbance (see Methods), indicates that newly-hatched broods may be very susceptible to disturbance.

There were no apparent differences in survival between species, impoundments or years of the study.

Sources of Mortality

No direct causes of brood loss among radio-marked birds were observed. One potential source of mortality was predation although attributing particular importance to it can be biased because predation is relatively more visible than factors such as starvation, disease or exposure to inclement weather. California Gulls (*Larus californicus*) and Ring-billed Gulls (*Larus delawarensis*) were observed taking ducklings from unmarked broods on several occasions, and Northern Harriers (*Circus cyaneus*) and Swainson's Hawks (*Buteo swainsoni*) were occasionally observed diving at hens and broods. Gulls have been shown to be a serious threat to eider broods (Milne 1974; Mendenhall 1976) and to duck broods hatched on islands where gulls are nesting (Dwernychuk and Boag 1972; Lynch and Toepfer 1975). The nearest nesting colony of California or Ring-billed Gulls to my study area was about 15 km away. Talent et al. (1983) recently provided evidence that mink predation may be an important cause of duckling mortality in North Dakota potholes.

In one instance a hawk was seen to dive in the vicinity of a radio-marked pintail hen and brood as they walked from the nest-site to water and a short time later the hen was found without her brood and in the company of a drake. Although hawk predation is suspected as the cause of brood loss, the presence of the drake also suggests the possibility of intraspecific interference. Raitasuo (1964) found that forced copulation attempts may be directed at hens with broods and cause brood breakup. This could be particularly important to brood survival in pintails because of the aggressive sexual pursuits exhibited by drakes (Smith 1968). One instance of male harassment of a Pintail hen with a brood was observed but the lone drake was not persistent and the hen was only forced to move a few meters.

Overland movement was not an important source of mortality, although it has often been considered a serious detriment to brood survival (e.g., Dzubin and Gollop 1972; Ball et al. 1975; MacLennan 1977; but see Talent et al. 1983). In the present study only one hen lost her brood prior to reaching water. The six other broods that hatched on the mainland reached water safely and the other eight broods were hatched on small islands. Dzubin and Gollop (1972: 130) estimated from "weekly censuses" that 48% of Mallard broods on their grassland study area did not survive the initial movement from nest to water. It seems plausible that some of the mortality which they attributed to overland movement was incurred after the brood reached water. Nest to water movement would not appear to be an extremely hazardous undertaking on the prairie because numerous hens select nest-sites which are further than 1 km from water (unpublished data). One radio-marked pintail hen moved her one-day-old brood 5.3 km between the two impoundments without loss (Duncan 1983).

During the course of this study, a few ducklings under two weeks of age were found dead with no visible signs of predation. Keith (1961) also reported finding duckling carcasses. The causes of death are speculative, possibly a result of brood disturbance, starvation, or exposure to inclement weather.

Conclusions

Total brood mortality can be considerable and must be taken into account in studies of duck production. Additional research on brood survival is required with emphasis on mortality under various habitat conditions and on the causes of duckling mortality.

Acknowledgments

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Using Eggshells to Determine the Year of a Common Loon, *Gavia immer,* Nesting Attempt

ROBERT ALVO and KENT PRIOR

Biology Department, Trent University, Peterborough, Ontario K9J 7B8

Alvo, Robert, and Kent Prior. 1986. Using eggshells to determine the year of a Common Loon, *Gavia immer*, nesting attempt. Canadian Field-Naturalist 100(1): 114–115.

A simple method is described for determining whether a Common Loon (*Gavia immer*) nesting attempt occurred in the current year or in a previous year, based on the extent of fading of the outer shell surfaces.

Key Words: Eggshell, fading, nesting attempt, Common Loon, *Gavia immer*.

One of the major problems with conducting a survey of breeding Common Loons (*Gavia immer*) is the large area that must be surveyed to obtain a sufficient sample size. The number of visits to a particular nest is therefore often limited (Vermeer 1973; McIntyre 1975), and it is common to find nests only after the eggs have hatched or have been preyed upon. Since loon chicks are precocial, the eggshells are usually left on the nest by the parents (Olson and Marshall 1952), often remaining there for one or two years (personal observation). When a nest for which no previous records are available is found with eggshells, but without any yolk, albumen or egg membrane, it is sometimes possible to distinguish between a nesting attempt that occurred during the current year and one of a previous year. For example, old shells are often found buried under nest material; also, old nests are often disheveled and may have fresh growing vegetation. However, nests found during the year of the nesting attempt sometimes also show these characteristics. We report here a method for examining the extent of fading of the eggshells, which can be used to determine whether or not the nesting attempt occurred during the current year.

During a survey of breeding Common Loons in the Sudbury, Ontario, area, we collected eggshell fragments from nine nests for which it was known that eggs were laid in the 1982 season. Collections were made from all the nests between 4 July and 15 July 1982 (within three weeks of hatching or depredation), from six of the nests between 6 August and 20 August 1982, and from six of the nests between 30 May and 15 July 1983. Shells were wrapped in tissue paper and stored in glass jars at room temperature.

The outer shell surfaces of newly hatched eggs did not change noticeably over the storage period, as evidenced by comparisons with fresh shells. Comparisons of shell fragments for the six nests from which collections were made twice in 1982 indicated that the outer surfaces of the shells either did not fade through the breeding season, or faded only slightly in small areas (Figures 1A, 1B). However, comparisons of shell fragments for the six nests from which collections were made in 1982 and 1983 indicated marked fading of the outer surfaces over the winter (Figure 1C). The black spots of the shells collected in 1982 were dark and sharply outlined against a greenish-brown background, whereas the spots were lighter and blended in with a faded tan background in the shells collected in 1983. The latter shells were smooth and dull, while the former were porous and shiny. Although shells that were face down in the nest tended to develop areas of fading more quickly during the breeding season than shells that were face up, both developed marked fading by the following breeding season.

FIGURE 1. (A, B, C from left to right) Contrast between shell fragments of Common Loon eggs collected the year the eggs were laid (A, B) and collected a year after laying (C). See text for details.

It is therefore possible to determine whether a Common Loon breeding attempt occurred in the current year or in a previous one, as long as some shells are present. In the absence of eggshells, other methods can be used with lower certainty.

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Field Observations of a Possible Hybrid Murre *Uria aalge* X *Uria lomvia*

T. R. BIRKHEAD[1], S. D. JOHNSON, and D. N. NETTLESHIP

Canadian Wildlife Service, Bedford Institute of Oceanography, P.O. Box 1006, Dartmouth, Nova Scotia B2Y 4A2
[1]Permanent address: Department of Zoology, University of Sheffield, Sheffield 210 2TN, England

Birkhead, T. R., S. D. Johnson, and D. N. Nettleship. 1986. Field observations of a possible hybrid murre *Uria aalge X Uria lomvia*. Canadian Field-Naturalist (100)(1): 115-117.

An adult murre (*Uria* sp.), with features intermediate between *U. aalge* and *U. lomvia*, was observed breeding with a Thick-billed Murre at the same site for three consecutive years in southern Labrador. Certain morphological and behavioural characteristics suggest that it was a hybrid.

Key Words: Murres, *Uria aalge, U. lomvia*, hybridization, Labrador.

During a detailed study of Common Murres, *Uria aalge*, and Thick-billed Murres, *U. lomvia*, at the Gannet Clusters, Labrador (53°56′N, 56°32′W) we located a murre which we were unable to designate as either *aalge* or *lomvia*. The existence of and problems of identifying hybrids between Common and Thick-billed Murres have been discussed by Tschanz and Wehrlin (1968), Cairns and deYoung (1981), and Sluys (1983). Here we present our observations of an unusual murre and discuss the likelihood of its being a hybrid. Observations were made from a blind approximately 50 m from the bird. It was not possible to get any closer without causing disturbance, nor (because of the distance) to obtain good photographs of the bird.

The bird was first identified as distinctive by S.D.J. on 16 July 1982, and was subsequently observed almost daily until late August. In 1983 it returned to the same breeding site and was seen almost daily from 24 May until 16 August. In 1984 the bird shared incubation duties at the same site throughout the entire period of observation: 1–15 July. In all three years it was paired to a Thick-billed Murre, and from copulations in 1982 and 1983 was seen to be a female. The pair bred on a ledge ($\leqq 1$ m^2 in area) on which there were 10 and 4 pairs of Common and Thick-billed Murres, respectively. In 1982 the pair produced an egg, but lost it; in 1983 an egg was laid on 18 June and hatched on 22 July, and the chick fledged on 13 August. In 1984 the pair incubated an egg throughout the 15 days of observation.

We consider the bird a possible hybrid because it possessed characteristics of both species. The Gannet Clusters breeding colony comprises about 76 000 Common Murres and 1900 Thick-billed Murres (D. N. Nettleship et al., unpublished data) which served as standards for comparison with the possible hybrid. Its dorsal plumage colour, posture and bill shape were all intermediate between *Uria aalge* and *U. lomvia*. Usually we had no problems distinguishing

TABLE 1. Summary of features of a possible hybrid murre and its chick.

Character	Most similar to *Uria lomvia*	Intermediate	Most similar to *Uria aalge*
Dorsal plumage colour		+	
Standing posture*		+	
Bill shape		+	
White line on upper mandible		+	
Bill tip colour			+
Throat plumage	+		
Bridled (part)			+
Chick plumage	+		

*See Spring 1971: Figure 1.

the species by their coloration. The bird possessed a white auricular groove on each side of its head, similar to the 'bridle' of some Common Murres (Jefferies and Parslow 1976). The white marking was relatively pale and ran behind the eye only, not around it as in a typical bridled murre. Although we have occasionally seen Common Murres with pale bridles, there are no records of Thick-billed Murres possessing them. The bird had a white line on both sides of the edge of its upper mandible (a Thick-billed Murre feature); the line was narrower than in most *lomvia* we have seen, but more obvious than those which sometimes occur on Common Murres (Sergeant 1951; Sluys 1983; this study). In Thick-billed Murres the bill tip is horn-coloured (i.e. translucent yellowish-brown; see also Sluys 1983); in our bird the bill tip was dark, and therefore resembled a Common Murre. The throat pattern showed an inverted "V" of white, similar in acuteness of angle to *lomvia*; Cairns and deYoung (1981) and Sluys (1983) pointed out that this is a poor distinguishing characteristic as it depends very much on the birds' position. The young of Common and Thick-billed Murres also differ in their plumage (Tuck 1961: 155; Birkhead and Nettleship 1985), and the 1983 chick more closely resembled a *lomvia* chick, which is consistent with the female parent being a hybrid. The main characteristics of this possible hybrid adult female are summarized in Table 1, and some of its features illustrated in Figure 1.

We obtained the opinions of two other observers, both of whom were familiar with Common and Thick-billed Murres. Without telling them of the existence of the "hybrid", we asked them to count the number of *aalge* and *lomvia* on the ledge when the bird was present. One counted the bird as a Common Murre (because of its bridle); the other considered it to be a Thick-billed Murre (because it was paired to a Thick-billed Murre). On being shown the bird, both agreed that it was difficult to designate as one species rather than the other.

Assuming that hybrids occur very occasionally, how might they arise? One first possibility is misdirected parental care. On ledges where both species breed in close proximity, the possibility exists of eggs becoming mixed up and young then being reared by the 'wrong' parents. If that occurred the young bird might become sexually imprinted on the other species (its foster parents), as documented in other species (Harris 1970). As a result, at sexual maturity it may attempt to pair with the "wrong" species. The mixed pair observed by Tschanz and Wehrlin (1968) may have arisen in this way. Another possibility is through

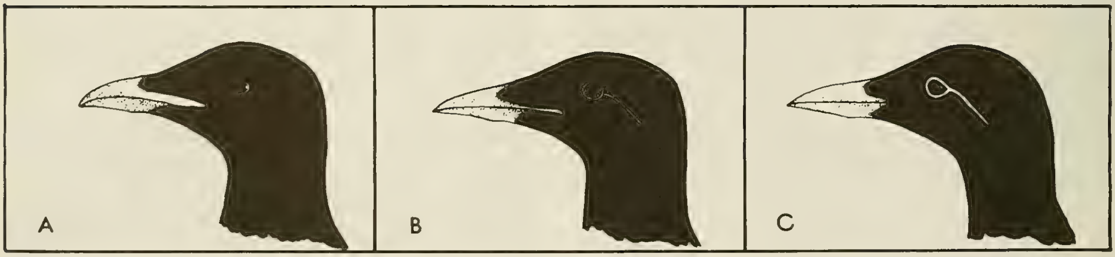

FIGURE 1. Summary of head features of (A) Thick-billed Murre, (B) possible hybrid murre, and (C) Common Murre (bridled).

forced interspecific mating. In both murre species, copulations with birds other than mates are common (Birkhead 1978; Gaston and Nettleship 1981; Birkhead et al. 1985), and on one occasion during this study, we saw a male Common Murre mount and make prolonged cloacal contact with a Thick-billed Murre.

Visual records are inconclusive evidence for the existence of a hybrid. But even had we been able to capture or collect the bird discussed in this note, we believe that it would be difficult to state categorically that it was a hybrid on the basis of its morphological features alone.

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"Brewster's" Warbler, *Vermivora chrysoptera* X *pinus* Backcross, Breeding in Huntingdon County, Quebec

PIERRE BANNON

1517 Leprohon Street, Montreal, Quebec H4E 1P1

Bannon, P. 1986. "Brewster's" Warbler, *Vermivora chrysoptera* X *pinus* backcross, breeding in Huntingdon County, Quebec. Canadian Field-Naturalist 100(1): 118–119.

A male "Brewster's" Warbler was seen with a recently-fledged young in Huntingdon County, Quebec, in June 1984, the first known breeding record for this hybrid in Quebec.

Key Words: "Brewster's" Warbler, *Vermivora chrysoptera* X *pinus*, breeding, Quebec.

On 25 June 1984, while observing birds along a side-road through a large tract of second-growth forest in southern Huntingdon County, Quebec (45°02′N, 74°05′W), my attention was drawn to a very agitated warbler-like bird giving repeated alarm notes. At first, I identified the bird as a female Golden-winged Warbler (*Vermivora chrysoptera*). However, closer examination revealed a bird with completely white, unmarked underparts and a narrow black line through the eye; the crown was bright yellow, and the upperparts and the wings were blue-gray, the latter with two yellow wing bars; flashes of white were visible in the outer tail feathers when the bird was flying. I then realized that the bird was a "Brewster's" Warbler (*Vermivora chrysoptera* X *pinus*). An examination of pictures in three field guides (Peterson 1980; National Geographic Society 1983; Farrand 1983) convinced me that I had seen a typical male "Brewster's" Warbler of the second generation, that is, the offspring of a cross between a first-generation "Brewster's" and a Golden-winged Warbler.

As I continued to study the bird, it exhibited behavior characteristic of an adult attending young or in the immediate vicinity of its nest. It constantly gave alarm calls and rapidly quivered its wings when perched, as though it was ill, thus trying to draw my attention towards itself. After a search of 10 to 15 minutes, I flushed a recently-fledged young bird that was well-concealed in the undergrowth along the road; the young bird flew directly across the road and again disappeared in the ground vegetation. I obtained only a brief glimpse of the young bird; it was rather dark on the back and smaller than a recently-fledged Brown-headed Cowbird (*Molothrus ater*), the only other species likely to be involved. It also gave a single call note just before taking flight; this call was unlike any call given by young Brown-headed Cowbirds. This bird, therefore, was probably a young warbler rather than a young cowbird.

As the young bird flew across the road, the adult followed it in an extremely agitated manner and perched in a tree above the spot where the young had hidden. I was unable to locate the young bird after a search of 10 to 15 minutes. On returning about an hour later, I relocated the adult deeper in the woods, but I was again unable to find the young.

This sighting constitutes strong evidence for the breeding of the "Brewster's" Warbler in southern Huntingdon County. Golden-winged Warblers are locally common breeding birds in this area (manuscript in preparation) and the young was quite probably the offspring of a backcross between the male "Brewster's" hybrid and a female Golden-winged Warbler. Blue-winged Warblers (*Vermivora pinus*) are not known to nest in Quebec, and extensive work in Huntingdon County during the summer of 1984 failed to reveal the presence of that species.

In Canada, the "Brewster's" Warbler nests in southern Ontario, with several breeding records recently published. A "Brewster's" hybrid was paired with a Golden-winged Warbler at Long Point in a successful nesting in June 1982 (Weir 1982), and near Peterborough, a pair of "Brewster's" fledged young in July of the same year (Carpentier 1983). Also a Blue-winged Warbler was paired with a "Brewster's" hybrid near Lynedoch, where breeding was confirmed during the summer of 1983 (Weir 1983). Several sightings of the "Brewster's" Warbler have also been reported from eastern Ontario, notably from Kingston where breeding is suspected but not confirmed (Quilliam 1973; Weir and Quilliam 1980). The sighting described here provides the first known breeding record for this hybrid in Quebec.

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The Great Plains Toad, *Bufo cognatus*, an Addition to the Herpetofauna of Manitoba

WILLIAM B. PRESTON

Manitoba Museum of Man and Nature, 190 Rupert Avenue, Winnipeg, Manitoba R3B 0N2

Preston, William B. 1986. The Great Plains Toad, *Bufo cognatus*, an addition to the herpetofauna of Manitoba. Canadian Field-Naturalist 100(1): 119–120.

A calling male *Bufo cognatus* was collected at approximately 2400 hours on 3 July 1983 at Lyleton, Manitoba. This record extends the range of the species northward by approximately 80 km and brings the total number of species of amphibians in Manitoba from 13 to 14.

Key Words: Great Plains Toad, *Bufo cognatus*, first record, Manitoba, range extension.

On the evening of 3 July 1983, while collecting Plains Spadefoots (*Scaphiopus bombifrons*) with the assistance of J. L. Murray and B. Ratcliff at Lyleton, Manitoba, I heard the pulsating, metallic trill of the Great Plains Toad (*Bufo cognatus*) nearly 1 km to the west, amid a large chorus of *S. bombifrons*. On 2 July, 32 mm of rain had fallen during a thunderstorm. The toad was calling from the edge of a temporary pool approximately 15 to 20 cm in depth, one of two such pools in a low part of a sandy, planted field 1 km west of Lyleton (49°03′N; 101°11′W). The bottoms of both pools were vegetated and the water was clear. The toad (MMMN catalogue number 1.4–312), 81.1 mm in total length, was collected at approximately 2400 hours. The air (1 m) and water (surface) temperatures at 0053 hours were 14.2°C and 17°C respectively. In addition to *S. bombifrons* and the Boreal Chorus Frog (*Pseudacris triseriata maculata*), I could hear distant calls of the Canadian Toad (*Bufo americanus hemiophrys*).

At 0100 hours, B. Ratcliff, who had left earlier, returned and informed me that he had heard another *B. cognatus* calling approximately 0.8 km to the north but could not locate it. I later investigated but heard no calls.

This toad brings the total number of species of amphibians in Manitoba from 13 (Preston 1982) to 14, and represents a range extension of approximately 80 km from the nearest previously known locality in northeastern McHenry County, North Dakota (Wheeler and Wheeler 1966). One may wonder why a toad as large as this and with such a loud and distinctive call has gone unnoticed until this time. As Bragg (1940) has observed, during his study of this species in Oklahoma, these toads are mainly nocturnal, spending weeks at a time underground during dry conditions. Also, breeding occurs only after rain if the air temperature is 12°C or higher and only in shallow, temporary pools, preferrably with clear water. Optimum conditions do not necessarily occur every year and several years may pass without the occurrence of breeding. Bragg (1950), in 13 years of observation of this species in Oklahoma, noted a total of five years with no successful breeding and three with poor success. He observed a period of five years between years of very successful breeding. These factors would certainly tend to preclude sightings by casual observers.

There is also the possibility that this species has arrived in Manitoba relatively recently. Wheeler and Wheeler (1966) did not report it from the tier of counties adjacent to Manitoba, although this may have equally been due to the elusive nature of this species.

Bufo cognatus could be expected in the southern Red River valley in Manitoba as well, for Breckenridge (1944) "heard calls thought to be those of the plains toad in Kittson County [Minnesota], but was unable to secure specimens of them there." Kittson County is adjacent to the Manitoba border. Cook (1960, 1966) reported this species from southwestern Saskatchewan. The nearest reported occurrence in Saskatchewan is from the Big Muddy area (49°03′N; 104°51′W) approximately 240 km to the west (Secoy and Vincent 1976). On the basis of this Manitoba record, it could be expected to occur in southeastern Saskatchewan as well.

Acknowledgments

I wish to thank John L. Murray for alerting me to the conditions that led to the collection of this toad, as well as for field assistance, and Brian Ratcliff for field assistance. It was Brian who first reached the toad. Ivan Murray kindly allowed us access to his farm, on which this collection was made. I thank R. E. Wrigley, F. R. Cook, and two anonymous reviewers for reading the manuscript and offering helpful suggestions.

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First Canadian Record of the Scrub Jay, *Aphelocoma coerulescens*

R. WAYNE CAMPBELL

Vertebrate Zoology Division, British Columbia Provincial Museum, Victoria, British Columbia V8V 1X4

Campbell, R. Wayne. 1986. First Canadian record of the Scrub Jay, *Aphelocoma coerulescens*. Canadian Field-Naturalist 100(1): 120–121.

A Scrub Jay (*Aphelocoma coerulescens*) photographed about 40 km southeast of Vancouver, British Columbia, on 8 November 1981 represents the first documented occurrence of this species in Canada.

Key Words: Scrub Jay, *Aphelocoma coerulescens*, British Columbia, first record.

The Scrub Jay (*Aphelocoma coerulescens*) generally ranges through southwestern North America and is resident north to southwestern Washington (A.O.U. 1983). Although considered sedentary, this species had been reported recently at Seattle, Washington, only 175 km south of British Columbia (Hunn and Mattocks 1978). The Scrub Jay has not been recorded previously in Canada (Godfrey 1966; personal communication 1981). The A.O.U. (1983) listed it as casual in southwestern British Columbia on the basis of the evidence now presented in this account.

On 8 November 1981 I received a telephone call from L. Williams who reported a "strange blue and white bird, about the size of a robin," in a private yard in Langley, British Columbia. I visited the area, about 40 km southeast of Vancouver, in the late afternoon and located a Scrub Jay among the lower branches of a tall ornamental shrub. I watched the jay for about 40 minutes before it moved into the open where photo-

graphs could be taken. Several 35 mm colour slides were obtained. Two (BCPM Photo Number 747) were added to the provincial photo-records collection (see Campbell and Stirling 1971), which is now housed in the British Columbia Provincial Museum. The jay moved along a hedge of deciduous shrubs to a small patch of Red Alders (*Alnus rubra*) where it was last seen. The bird could not be located the following day (9 November) nor on five subsequent searches from mid-November 1981 through early January 1982.

The extra-limital Scrub Jay in Seattle was also first seen in winter (24 December 1977) but that bird remained there for just over a year, frequenting an alder-covered hillside, until 6 January 1979 (Hunn and Mattocks 1978; Mattocks 1979).

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Black-billed Magpie, *Pica pica*, Predation on Bats

WESLEY M. HOCHACHKA[1] and CRAIG S. SCHARF[2]

Department of Zoology, University of Alberta, Edmonton, Alberta T6G 2E9
[1]Present Address: Department of Zoology, University of British Columbia, Vancouver V6T 2A9.
[2]Present Address: Department of Biological Sciences, State University of New York, Plattsburgh, New York 12901.

Hochachka, Wesley M., and Craig S. Scharf. 1986. Black-billed Magpie, *Pica pica*, predation on bats. Canadian Field-Naturalist 100(1): 121–122.

In two of three cases of magpie predation on bats observed on the University of Alberta campus, the magpies involved were roughly two months post-fledging. Both roosting and flying bats were apparently captured.

Key Words: Black-billed Magpie, *Pica pica*, predation, bats, Alberta.

Like most corvids, Black-billed Magpies, *Pica pica*, are opportunistic omnivores (Goodwin 1976: 19), feeding mainly on insects when available (Bigot 1966; Tatner 1983). Other invertebrates, fruit, seeds, carrion, bird eggs, and various small birds and mammals are also eaten (Linsdale 1937: 52; Goodwin 1976: 175-176; unpublished data). Magpie predation on bats has been noted once (Boxall 1982), but no details were provided. Many reports of raptor predation on bats exist (Gillette and Kimbrough 1970: 281-282), but the only other corvids reported to prey on bats are Blue Jays (*Cyanocitta cristata*) observed taking flightless young bats (Allan 1947; Elwell 1962), and an African crow species (Rosevear 1965: 98). This note provides additional records of the use of bats as food by magpies, giving information on the ages of the magpies involved and the methods of capture used.

During a study of magpie ecology we obtained three records of magpies eating bats. All three observations were on the University of Alberta campus (53° 32′ N, 113° 32′ W) in Edmonton, and involved birds with unique colour band combinations. Two records were provided by outside observers, and the third incident was seen by W.M.H. The species of bat(s) involved is unknown; the most common species in Edmonton are the Little Brown (*Myotis lucifugus*) and Big Brown (*Eptesicus fuscus*) Bats (Smith 1979: 7-9).

The first record was on 15 August 1982 at 1200 MDT when two immature magpies, both roughly two months post-fledging, were seen consuming a bat; no capture was observed.

The second case was on 24 August 1982 at *ca.* 1000 h. W.M.H. observed a juvenile magpie (not one of the two involved in the first incident, but again roughly two months post-fledging) fly to the ceiling of an open-sided, roofed walkway. As the magpie approached the ceiling, it turned so that its feet and bill were directed towards the ceiling. The magpie returned to the ground with a bat in its bill. Magpie and bat fell roughly vertically, despite the magpie's attempt to fly off; the bat was possibly either relatively heavy for the magpie (suggesting a large bat species?),

or an awkward load. At no time was the bat observed to move, presumably being incapacitated on impact. Such opportunistic predation on a roosting bat is not unexpected in magpies, as they are resourceful predators.

A more surprising observation came on 19 May 1983 at ca. 1630. A magpie was seen pursuing a flying bat for about half a minute; bat and magpie disappeared behind some shrub, and when the observer approached the point of disappearance he found the magpie eating a bat. The colour bands on the bird were not recorded. However, this bird was unlikely to have been one of those involved in the 1982 sightings; in May, territories are vigourously defended by their adult (greater-than-one-year-old) owners, and the observation came from a known magpie territory.

The incidents noted illustrate the versatility of foraging magpies. The 1982 observations show that even very young magpies have the ability to identify and use novel food items. More significant was the 1983 observation of aerial pursuit of a bat. Successful aerial pursuit of bats is known for birds such as gulls, hawks, falcons, and owls (Gillette and Kimbrough 1970; Holroyd and Beaubien 1983), which are highly dependant on their flying ability to obtain food. Magpies generally forage on the ground (Goodwin 1976: 175), and thus have little need for aerial foraging skills. That magpies can apparently successfully use aerial pursuit for prey capture is noteworthy. Such opportunism and versatility in foraging has probably aided the Black-billed Magpie in becoming a prominent member of the fauna of Edmonton and other urban centres in the magpie's range.

Acknowledgments

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The Plains Spadefoot, *Scaphiopus bombifrons*, in Manitoba

WILLIAM B. PRESTON[1] and DAVID R. M. HATCH[2]

[1]Manitoba Museum of Man and Nature, 190 Rupert Avenue, Winnipeg, Manitoba R3B 0N2
[2]876 Elizabeth Road, Winnipeg, Manitoba R2J 1A8

Preston, William B., and David R. M. Hatch. 1986. The Plains Spadefoot, *Scaphiopus bombifrons*, in Manitoba. Canadian Field-Naturalist 100(1): 123–125.

Since few Manitoba specimens of *Scaphiopus bombifrons* existed in collections, this species was considered to be rare in the province. Information is presented on recent collections near Lyleton, Oak Lake and Virden (the latter a new locality for the province) with details on breeding sites and dates in Manitoba to show that it can be seasonally and locally abundant.

Key Words: Plains Spadefoot, *Scaphiopus bombifrons*, breeding, Manitoba, distribution.

Until recently, few specimens of the Plains Spadefoot (*Scophiopus bombifrons*) were known in collections from Manitoba (Preston 1982). On this basis C. van Zyll de Jong and R. Nero in a status report (1971, personal communication) considered this species to be rare, as did Nero and Wrigley (1977). This is perhaps understandable, as spadefoots, due to their nocturnal habits and their propensity for breeding only after heavy rain (approximately 13 mm or more according to Bragg 1965) and sufficiently high temperatures (10°C), are not often seen by the casual observer. Study of these animals is especially difficult if the researcher's headquarters are a considerable distance from spadefoot habitat, but partly through the kindness of local observers such as J. L. C. Harrison of Oak Lake and J. L. Murray of Lyleton new information reported here has been obtained.

The first collection of the Plains Spadefoot in Manitoba consisted of three immature specimens from southwest of Dauphin, collected 25 July 1935 by C. M. Sternberg (Cook 1960; Cook and Hatch 1964). The next collection was a male collected 22 July 1963 southwest of Oak Lake by D.R.M.H. while hoeing in the garden (Cook and Hatch 1964). In 1971, W.B.P. received 6 of 18 tadpoles collected on 27 July at Oak Lake (49°46′N; 100°38′W) by J. L. C. Harrison and D. McDonald. Four were preserved. A heavy rain had occurred at Oak Lake on 10 June (J. Harrison, personal communication) and it is most likely that these specimens were the offspring of spadefoots which had bred during that rain.

Even when sufficient rain does fall and the temperature is sufficiently high, breeding may not necessarily be successful. There was a heavy rain in Lyleton (49°03′N; 101°11′W) on 12 June 1972, and on the evening of 13 June, V. H. Scott and J. L. Murray (personal communication) heard a large chorus of spadefoots. No calls were heard on 14 or 15 June, when the temperatures were lower. W.B.P. visited the site on 26 June but the pool, which consisted of a low flooded area in a field, had disappeared.

On 3 June 1973, J. L. Murray informed W. B. P. that 91 mm of rain had fallen in Lyleton on the previous day and that the spadefoots were calling. However, there was no opportunity to investigate further. The next breeding period for which information was received was not until 4 August 1981, when 68 mm of rain fell in Lyleton in the late evening. The spadefoots began calling before morning and continued day and night until the evening of 7 August, by which time all of the water observed had disappeared (J. L. Murray, personal communication). Breeding would seem to have been unsuccessful except that on 30 September, J. L. Murray found an immature spadefoot, approximately 19 mm in length, at his doorstep (this is the general size of newly transformed spadefoots; W.B. Preston, in preparation). Perhaps not all of the pools had dried up and this individual was from one of these; however, breeding may have had occurred earlier in the summer, although no calls had been noted, and the amount of rainfall had been low.

On 15 and 16 May 1982, at least 25 mm of rain fell in Lyleton and spadefoots called on the evenings of 17 and 18 May. It was too windy to hear calls on 19 May and no calls were heard on 20 May (J. L. Murray, personal communication). W.B.P. visited the site, a low area in a fallow field, on 9 June and there was a small amount of water present, but most likely from a more recent rain on 6 June. No tadpoles were seen.

In July 1982 W.B.P. had an opportunity to study spadefoots in the field when approximately 43 mm of rain fell at Oak Lake on 15 July and spadefoots were reported calling at approximately 2400 h CDT (L. Hatch, personal communication). A further 23 mm of rain fell on the following evening at which time D.R.M.H., using a flashlight, counted 17 individuals in one of three temporary pools on his father's farm, southwest of Oak Lake. By the time W.B.P. arrived, on 17 July, the temperature had dropped considera-

bly. At 2240 h CDT the temperature of the air (1 m) was 14.6°C and the water (surface) 18.5°C. At 2300 h CDT we heard only a few individuals calling. W.B.P. collected one of two males (51.7 mm total length) calling in one of the three pools, 15 to 20 cm in depth.

On 18 July 1982, we collected several egg masses for observations on tadpole growth and development (W.B. Preston, in preparation). At 1600 to 1700 h CDT the water temperature of the three pools ranged from 29.4°C to 31.3°C. That evening, at 2300 h, no calls could be heard from the three pools. Faint calls could be heard in the distance, but the source could not be located.

The next specimens collected were two males taken at 0030 h CDT, 8 June 1983, 2 km east of Virden (49°51′N; 100°56′W) by R. E. Wrigley, J. Dubois, and J. Wiley, while searching for pocket mice (*Perognathus*). The area was a sandy, recently seeded rye field with much bare ground. The air temperature was estimated to be approximately 8°C and there had been a light rain earlier in the evening. No calls were heard. This is not unusual spadefoot behaviour since Bragg (1956) observed that "whenever conditions are right (that is, relatively cool and moist at the surface of the ground) they emerge and forage...returning to their burrows before daylight." W.B.P. has collected Great Basin Spadefoots (*Scaphiopus intermontanus*) in British Columbia under similar conditions (but at warmer air temperature) on several occasions. Virden represents a new, although not unexpected locality for spadefoots in Manitoba. Cook (1965) reported a DOR ["Dead On Road"] sight record by A. W. F. Banfield made 23 August 1964, 6.4 km west of the Manitoba border on Highway 1 (approximately 50°04′N; 101°31′W).

A thunderstorm in Lyleton on 2 July 1983 dropped 32 mm of rain and spadefoots began to call that evening (J. L. Murray, personal communication), providing another opportunity for study. W.B.P. arrived in Lyleton on 3 July and, with the assistance of J. L. Murray and B. Ratcliff, collected a sample of 13 specimens betwen 2300 h and 0100 h (4 July). At 2300 h the air (1 m) and water (surface) temperatures 0.7 km south of Lyleton were 15.5°C and 16°C, respectively. One male was found at this site in a shallow pool in a sandy, planted field. The remainder of the specimens were taken from two adjacent pools in a sandy, planted field 1 km west of Lyleton, on the property of I. Murray. The large chorus at this location could be heard from the first site. At 0053 h on 4 July the air (1 m) and water (surface) temperatures at the second location were 14.2°C and 17°C, respectively. On 4 July several egg masses were collected at the latter site for observation of tadpole growth and development (W.B. Preston, in preparation). The water at these pools was clear, 15 to 20 cm in depth, and the bottoms were vegetated. This location was again visited at 2245 h, at which time the air temperature was 10.4°C (1 m) and the water temperature 16.2°C (surface). No spadefoots were heard calling.

As an indication of the numbers of individuals attracted to breeding sites, E. J. Bredin (personal communication) counted 108 spadefoots on two sections of gravel road south of Oak Lake at approximately 0300 h after heavy rain on 22 July 1981. He heard large numbers of spadefoots calling from roadside ditches and adjacent fields at the same time. Returning to the site that evening, he again noted large numbers on the roads.

Although the known breeding sites for spadefoots in Manitoba have not been monitored continuously as Bragg (1965) has done in Oklahoma, it does seem evident from these few observations that in a particular population of spadefoots breeding may not occur every year and may not be successful when it does occur. In some cases there had been sufficient rainfall but the temperature had evidently been too low. In other instances breeding may have occurred but the pools had dried up before tadpole development could be completed. During optimum breeding conditions, however, spadefoots are not uncommon in southwestern Manitoba.

Spadefoots are adapted to the vagaries of the weather. Bragg (1950) observed that not all females in a given population breed at once. Thus there may be more than one breeding period for the species in a year, should the proper conditions be presented. Further, during each year at Lyleton for which there is information, the breeding sites were in different areas. It is possible that pools form in different fields from year to year due to variations in tilling practices. Although this species has been extensively studied in Oklahoma (Bragg 1965), in southwestern Canada the Plains Spadefoot reaches the northern limits of its range and warrants further study.

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We wish to thank J. L. C. Harrison and J. L. Murray for much information as well as field assistance from the latter, B. Ratcliff for field assistance, and L. Hatch and I. Murray for kindly permitting us to use their property. We thank R. E. Wrigley, F. R. Cook and an anonymous reviewer for reading the manuscript and making valuable suggestions.

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The Second and Third Records of the Black Drum, *Pogonias cromis*, from the Canadian Atlantic

JOHN GILHEN

Nova Scotia Museum, 1747 Summer Street, Halifax, Nova Scotia B3H 3A6

Gilhen, John. 1986. The second and third records of the Black Drum, *Pogonias cromis*, from the Canadian Atlantic. Canadian Field-Naturalist 100(1): 125–126.

Two Black Drums, *Pogonias cromis*, are here reported as the second and third records for Nova Scotia and Canada. One, 125 cm in total length, was captured in a herring gill net in Lockeport Harbour, Shelburne County, Nova Scotia (43°42′N, 65°06′W) on 22 July 1978 by Michael Swim. The second, 126 cm in total length, was found dead on the surface in Petpeswick Inlet, Halifax County, Nova Scotia (44°43′N, 63°10′W) on 28 November 1978 by Richard Young.

On rend compte ici de deux grands tambours, *Pogonias cromis*, la deuxième et la troisième observation de cette espèce en Nouvelle-Ecosse et au Canada. Le premier, mesurant 125 cm de longueur totale, fut capturé a l'aide d'un filet maillant à hareng à Lockeport Harbour, comté de Shelburne, Nouvelle-Ecosse (43°42′N, 65°06′O) le 22 juillet 1978 par Michael Swim. Le deuxième, mesurant 126 cm de longueur totale, était mort en surface à Petpeswick Inlet, comté d'Halifax, Nouvelle-Ecosse (44°43′N, 63°10′O) le 28 novembre 1978, et était trouvé par Richard Young.

Key Words: Black Drum, *Pogonias cromis*, new records, Canadian Atlantic.

The Black Drum is a member of the family Sciaenidae which contains about 50 genera and about 210 species (Nelson 1984). The Black Drum is primarily a bottom-associated carnivorous fish that can produce drumming-like sounds by the action of special muscles which insert on the wall of the swim bladder (Johnson 1978). Its range is from the Gulf of Maine to the Gulf of Mexico and southern Brazil to Argentina (Chao 1978).

The Black Drum has an oblong and deep body. The dorsal profile is elevated while the ventral profile is nearly straight. It has a large head with a conical snout that does not project conspicuously in front of the upper jaw. The snout has five upper pores and five marginal pores. The lower jaw has five pores and 12 or 13 pairs of small barbels. The mouth is moderate, horizontal and slightly inferior. The teeth are in a villiform band on both jaws. The lower pharyngeals are very large, fully united and with coarse, molariform teeth. The gill rakers are very short. The body is covered with relatively large scales and there are 41 to 46 pored scales along the lateral line. The first dorsal fin has 10 spines; the second has 19 to 23 soft rays preceded by one short spine. The anal fin has 5 to 7 soft rays preceded by two spines; the first is short, the second is long and stout. The swim bladder is very complex with many inter-connected diverticula. There are 24 vertebrae (Chao 1978).

The first occurrrence of a Black Drum in the Canadian Atlantic was recorded by Bleakney (1963). The specimen was taken in a weir at Halls Harbour (Bay of Fundy), Kings County, Nova Scotia. This is 350 miles north of the range limit of Massachusetts Bay given by Bigelow and Schroeder (1953). It was captured sometime during July or August 1947, and a mount prepared by Bleakney measured 39¼ inches (99.6 cm). Bleakney reported that the fisherman who captured this fish likened the sounds it produced to the drum-

ming of a Ruffed Grouse (*Bonasa umbellus*).

The second and third specimens in Canadian waters are reported here. A specimen, 125 cm in total length, was captured in a herring gill net in Lockeport Harbour, Shelburne County, Nova Scotia (43°42'N, 65°06'W) on 22 July 1978 by Michael Swim. Another, 126 cm in total length, was found dead on the surface in Petpeswick Inlet, Halifax County, Nova Scotia (44°43'N, 63°10'W) on 28 November 1978 by Richard Young. This specimen may have succumbed to the cool water temperatures. Both specimens have 12 pairs of barbels along the inner edges of the lower jaw. The head and a scale sample of each specimen are preserved and catalogued in the Nova Scotia Museum Ichthyology Collection (NSM978-158-1(1) and NSM978-160-1(1)).

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A Record of the Question Mark, *Polygonia interrogationis*, butterfly for Insular Newfoundland

BERNARD S. JACKSON

Memorial University Botanical Garden, Memorial University of Newfoundland, St. John's, Newfoundland A1C 5S7

Jackson, Bernard S. 1986. A record of the Question Mark, *Polygonia interrogationis*, butterfly for insular Newfoundland. Canadian Field-Naturalist 100(1): 126–127.

The Question Mark (*Polygonia interrogationis*) is reported as new to the Lepidoptera of Newfoundland on the basis of a photograph taken 21 September 1981 at St. John's.

Key Words: Question Mark, *Polygonia interrogationis*, Insular Newfoundland, Lepidoptera, Nymphalidae.

The Question Mark, *Polygonia interrogationis* (Lepidoptera: Nymphalidae), occurs over most of the United States with the exception of the Great Basin and the Pacific Coast region. East of the Rocky Mountains it is found sparingly at low elevations ranging from southern Canada and Nova Scotia south through Texas and Florida (Howe 1975). Neither Krogerus (1954) nor Morris (1980) record it from either insular Newfoundland or Labrador.

On 21 September 1981 an unknown butterfly was photographed by D. Barton in his garden in St. John's, Newfoundland (47°34'N, 52°43'W), while it was drawing nectar from a flowerhead of *Sedum spectabile* in the company of Red Admirals (*Vanessa atalanta*). The 35 mm Kodachrome slide was shown to me on 21 March 1983 and was tentively identified as a photograph of *Polygonia interrogationis*. Subsequently, J. Donald Lafontaine, Biosystematics Research Institute, Ottawa, verified the identification from the original transparency. He confirmed that it is of the summer form (with the pale hind wings and violet fringe) and therefore unmistakable.

The record constitutes the first authenticated sighting of the species for Newfoundland. This species is one of the Lepidoptera that migrate up and down the East Coast region of North America and in Newfoundland it would definitely be a seasonal immigrant unlikely to successfully overwinter here or elsewhere in Canada (Douglas C. Ferguson, Systematic Entomology Laboratory, U.S. Department of Agriculture,

FIGURE 1. Question Mark, *Polygonia interrogationis*, photographed by D. Barton 21 September 1981 at St. John's, Newfoundland.

personal communication). J. D. Lafontaine (personal communication) feels that it probably reaches Newfoundland and breeds for that summer one year in ten or twenty; but if it reaches Newfoundland only in late summer it may occur too late in the season to facilitate oviposition (personal observation).

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The Helleborine, *Epipactis helleborine* (Orchidaceae), in Northern Ontario

DANIEL F. BRUNTON

Southwick Drive, R.R. 3, Manotick, Ontario K0A 2N0

Brunton, Daniel F. 1986. The Helleborine, *Epipactis helleborine* (Orchidaceae), in northern Ontario. Canadian Field-Naturalist 100(1): 127–130.

The Helleborine, *Epipactis helleborine*, is the most successful of the small number of introduced orchids in Canada. It has become abundant in most of the limestone-based areas of southern Ontario and is found in lower numbers in scattered locations in the acidic Precambrian Shield of the province. First records for northern Ontario (St. Joseph's Island, Algoma District, and New Liskeard, Temiskaming District) are reported here. *E. helleborine* may now have occupied most of the Ontario range in which it can become a common and important species. It may still, however, become fairly common in parts of the Rainy River District of northwestern Ontario.

Key Words: *Epipactis helleborine*, northern Ontario, distribution.

The Helleborine, *Epipactis helleborine* (L.) Crantz, is one of the few introduced species of orchids to have become established successfully in North America (Luer 1975). It has been known in Canada since at least 1890 and is presently found across southern Ontario and Quebec and in southwestern British Columbia, where it has spread from material transplanted from the east (Scoggan 1978). It is still expanding its range in Ontario; two significant range extensions in the province and some aspects of its distribution are discussed here.

Distribution

Since it was first reported in 1890, *E. helleborine* has spread extensively and by the early 1950's was known commonly across southern Ontario from the mid Lake Erie area eastward (south of the Canadian Shield) to Kingston (Soper and Garay 1954). It was rare in eastern Ontario in that period, known only from a collection at Ottawa and from a few specimens from Leeds County. It is primarily a species of moist, calcareous ground but can be an aggressive colonizer of a variety of habitats and is very tolerant of shade.

Soper and Garay (1954) point out how the largely acidic substrates of the Canadian Shield have apparently presented a barrier to its northern expansion in Ontario. This may also be the case along the largely acidic Frontenac Axis bordering eastern Ontario. Helleborine appears to be largely confined to small, disturbed sites in less acid substrates (e.g. abandoned gardens, railway ditches, roadsides, etc.) on the Shield. It has become very common in the Ottawa area, however, since the mid 1950's (Greenwood 1967; Gillett and White 1978; personal observation) and is now also known on Manitoulin Island (Greenwood 1974; Morton 1977).

Figure 1 illustrates the approximate limits of range of *E. helleborine* in Ontario prior to 1955, based on the map in Montgomery (1956). It also illustrates the expansion of range of *E. helleborine* between 1955 and 1975, based on a review of the DAO, DFB, APM, TRT and CAN herbaria (acronyms from Boivin 1980), personal observations, and a review of a number of unpublished resource inventory reports from across south-central and central Ontario. This 1975 limit is approximate but appears to match quite closely that determined by P. M. Catling and R. E. Whiting in their detailed mapping of Ontario orchid distributions (P. M. Catling, personal communication). Two locations that indicate extensions of range (the dots marked 1981 and 1983 on Figure 1) can be described as follows:

1981, 11 August: 10–20 plants noted west of the site of Old Fort St. Joe (National Historical Site), St. Joseph's Island, Algoma District; in shallow soil over limestone in deep shade. *D. F. Brunton 3177*, CAN.

1983, 29 August: over 100 plants 7 km north of New Liskeard along Highway 11, Temiskaming District; in open, dry crevices in limestone bedrock. *D. F. Brunton 4716*, DAO.

Both of these collections represent first records for their respective Districts and constitute the first confirmed reports from northern Ontario. A popular wildflower book reports Helleborine from an unspecified location in Temiskaming district (Bryan and Newton-White 1978); this report may be based on the New Liskeard station.

The presence of both stations on limestone bedrock (and not on adjacent acidic gneissic substrates) is consistent with the site preference indicated in Ontario off the Canadian Shield.

Dispersal Characteristics

While the standard references to the orchid flora of the Great Lakes (*cf.* Case 1964; Luer 1975) agree that *E. helleborine* is most probably an introduction from Eurasia, the vehicle of this introduction is unspecified. Both of these authors include the possibility that it was intentionally introduced for its supposed medicinal values. Mockle (1955) describes it as a "vulnéraire" (i.e. used as an application on cuts or bruises) and Luer (1975) cites a report of its use in the treatment of gout. Marie-Victorin (1919) felt that its presence on Mount Royal at Montreal was attributable to its spread from abandoned herbal gardens. He stated that "... the gardens inside the pallisade usually contained the best drug plants in favor [sic] at the time. When cultivation [ceased] at that particular spot, the plants had very often gained a strong foothold and were able to persist for centuries. A striking example of this is the abundance of [*Epipactis*] *helleborine* ... on Mount Royal...".

Regardless of one's acceptance or rejection of Frère Marie-Victorin's speculation on the Canadian origin of the species, it seems clear that the first specimen in North America was collected near Syracuse, New York in 1879 and that by the early 1890's it had also been found at Toronto, Montreal, and Buffalo (Morong 1893; Penhallow 1893; and Marie-Victorin 1935; respectively). The pre-1900 records of *E. helleborine* appear to represent widely scattered stands. There is little evidence of the aggressive increase in population that has characterized this species after about 1930 (cf. Marie-Victorin 1935; Case 1964; Morris and Eames 1929; Soper and Garay 1954). It seems possible that a particularly large population must be established at a particular location before that population can generate a sufficient quantity of seed to insure the very rapid population increase that we have seen in the 1960's and 1970's. The fertility 'insurance' apparently provided by the effective cross-pollination system employed by *E. helleborine*, and its probable self-compatability (Catling 1983), undoubtedly contributes to its potential for rapid dispersal. Certainly *E. helleborine* can exist at very low population levels for extended periods of time (e.g. W. G. Dore 1977; personal observation).

Conclusions

Most of the limestone-based area of Ontario (excluding the subarctic/arctic where this temperate species is unlikely to survive) is now within the range of *E. helleborine*. It is reasonable to expect that new stations will be found in the Great Lakes — St. Lawrence Forest Region (cf. Rowe 1972) along the less acidic shores of Lake Huron and along the southern shores of Lake Superior. *Epipactis helleborine* may even become common on the limey clay plains in the Lake of the Woods region of northwestern Ontario. It is also likely to be found elsewhere in northern Ontario, but in small numbers as a roadside or railway weed or as a garden adventive. As an important element of the vegetation, *Epipactis helleborine* remains

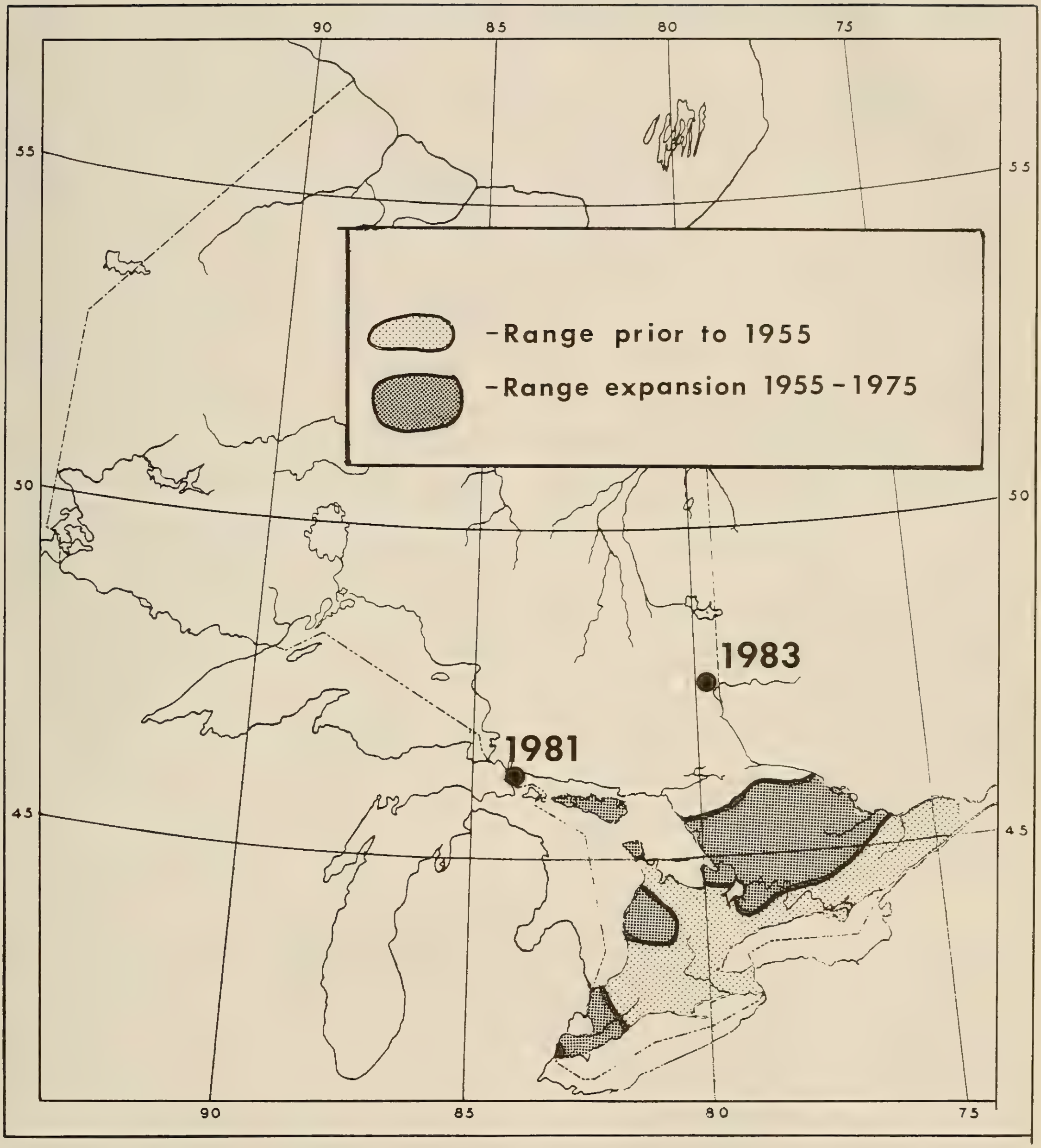

FIGURE 1. The distribution of Helleborine (*Epipactis helleborine*) in Ontario (dots with year represent recent range extentions: see text).

primarily a species of the limestone-based areas in the south of the province.

Acknowledgments

My thanks to the curators of the DAO, TRT, CAN, and APM herbaria, for permission to examine the material in their collections and to P. M. Catling for his help in securing literature and for showing me his map of the distribution of *Epipactis helleborine* in Ontario. I also thank C. Frankton and K. L. McIntosh, and referees J. Reddoch and P. M. Catling, for their constructive critiques of the manuscript.

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Addendum

A second, larger station of *E. helleborine* was recently found approximately 10 km south of the first New Liskeard stand. It is located at 47° 30′ N, 79° 39′ W along Highway 11, on the Haileybury–New Liskeard townline; *D. F. Brunton 6246*, 26 August 1985 (DAO, DFB) and is in virtually identical habitat to that of the 1983 collection.

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Editor's Note

Subsequent to the acceptance of this manuscript an additional contribution to the range of the species has appeared:

Soper, James, H., and **Linda Murray.** 1985. Helleborine — a 30-year update and analysis of its distribution in Ontario. The Michigan Botanist 24: 83–96.

Occurrence and Spawning of Pink Salmon, *Oncorhynchus gorbuscha*, in Lake Ontario Tributaries

R. M. DERMOTT and C. A. TIMMINS

Fisheries and Oceans, Pacific and Freshwater Fisheries, Great Lakes Fisheries Research Branch, Burlington, Ontario L7R 4A6

Dermott, R. M., and C. A. Timmins. 1986. Occurrence and spawning of Pink Salmon, *Oncorhynchus gorbuscha*, in Lake Ontario tributaries. Canadian Field-Naturalist 100(1): 131–133.

Pink Salmon were confirmed present in seven tributaries of Lake Ontario during the 1983 spawning period. Spawning occurred in three of the streams. Lake Ontario fish were smaller than fish from lakes Erie and Huron.

Key Words: Pink Salmon, *Oncorhynchus gorbuscha*, Lake Ontario, distribution, spawning.

Unlike other salmon in the Great Lakes, Pink Salmon, *Oncorhynchus gorbuscha*, originated from a single introduction in Thunder Bay, Lake Superior, during 1956 (Schumacher and Eddy 1960). By natural reproduction, normally in odd years, this species has extended its range throughout the upper Great Lakes, where, by 1975, it had become well established (Collins 1975; Kwain and Lawrie 1981).

First reports of the species in Lake Erie occurred during the late summer of 1979, when moderate numbers appeared in Young Creek, Ontario, while smaller runs were reported from tributaries in Ohio and Pennsylvania. During the same period, occurrences of the species were reported in several tributaries of western Lake Ontario: at Forty Mile Creek, Grimsby; Spencer Creek (Hamilton Harbour) and the Credit River (Figure 1). Several fish were also reported in South Sandy Creek, New York, on the eastern side of the lake. Subsequently, only two fish were reported in Lake Ontario during 1981 (Dermott 1982).

The normal life span of the species is two years, the adults enter streams to spawn during mid September, then die. The potential success of Pink Salmon in the lower Great Lakes is enhanced by their habit of spawning on gravel riffles in the lower reaches of tributaries. Furthermore, they are able to utilize streams, during the fall and winter, that become too warm for salmonids in summer, as the fry quickly leave the streams after hatching in early spring (Emery 1981; Kwain and Lawrie 1981). The distribution, feeding habits and behavior of the species in the open lakes is still unknown (T. Stauffer, Michigan Department of Natural Resources, unpublished, May 1981), as fish only appear off the river mouths during August of their second year.

Methods

An extensive survey for Pink Salmon was undertaken in tributaries of western Lake Ontario from 14 September until 2 October, 1983. Electroshocking was conducted in the lower reaches of streams using a portable 400 volt DC electroshocker. Most streams were examined for 2 km above the stream mouth or to the first barrier encountered. The number of fish present was estimated both visually and from angler reports. Specimens were retained for contaminant analysis and length-weight measurements. Data were compared with that of Pink Salmon collected by the Department of Fisheries and Oceans from Lakes Erie and Huron during 1983, and that from Lakes Superior and Erie in 1979 (Kwain and Lawrie 1981).

The number of redds with attendant Pink Salmon females was recorded. In order to determine vitality and provide information on early development, fertilized eggs from collected fish were maintained from 22 September until 16 December 1983 at the ambient temperature of a local stream. Thereafter the eggs and fry were maintained at 1°C with a 9–h light regime.

Results and Discussion

Seven tributaries along the north and western shore of Lake Ontario had confirmed captures of Pink Salmon during September 1983 (Figure 1). The species was confirmed for the first time in four streams; Bronte Creek, Bowmanville Creek, Wilmot Creek, and the Ganaraska River. A single fish had been reported previously from Shelter Valley Creek during 1981 (Dermott 1982), while in September 1983 several fish were present in the stream. Several fish, presumably on their way to the river, were captured by anglers off the Credit River. This stream had reports of fish in both 1979 and 1981. No fish were reported from any New York tributaries during 1983 (C. Schneider, New York Department of Environmental Conservation), in spite of reports of the species in the South Sandy River during 1979.

The largest runs were reported in Bronte Creek,

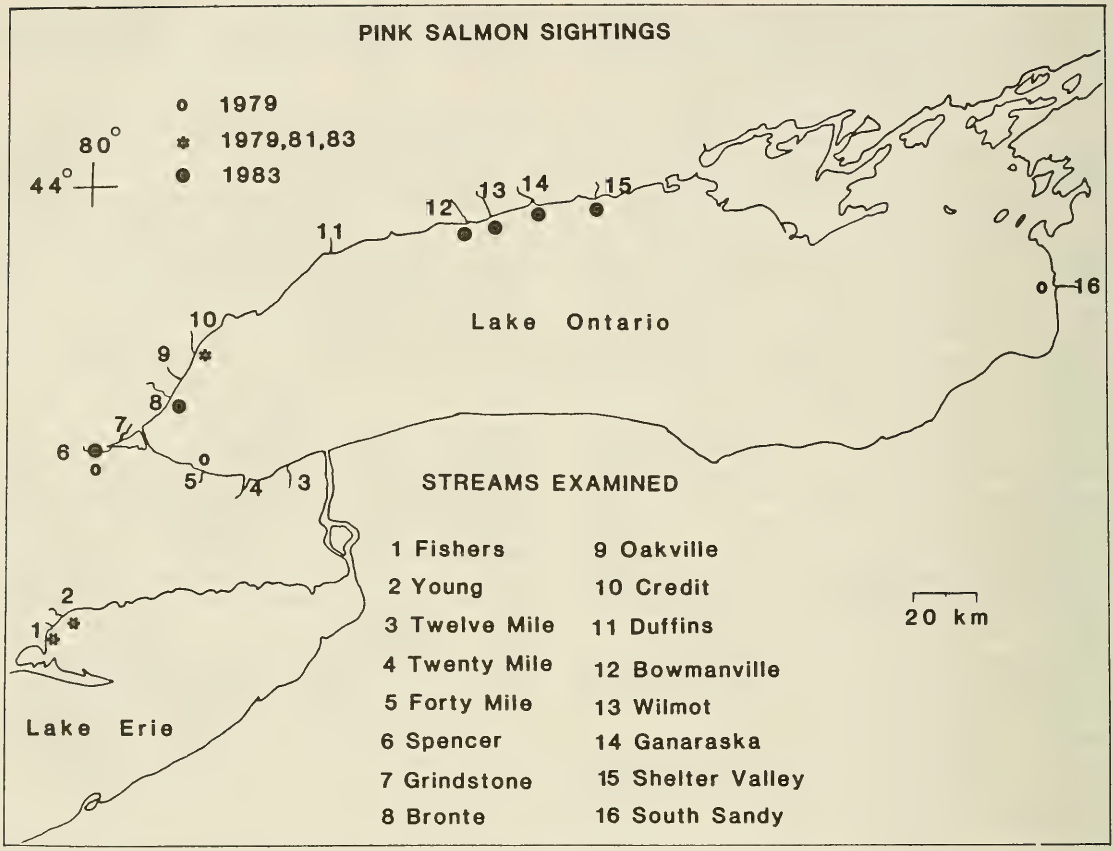

FIGURE 1. Distribution of sightings of Pink Salmon, 1979-1983.

Wilmot Creek and the Ganaraska River (Table 1). Angler reports indicated several hundred fish present (Oshawa Times, 24 September 1983). However, electroshocking of Bronte and Wilmot Creeks during the same week determined the runs were much smaller, with an estimated 40 fish in Wilmot Creek and few remaining in Bronte Creek. Liberal estimate of the adult population in Lake Ontario during 1983 was approximately 200 fish.

TABLE 1. Relative abundance of Pink Salmon in Lake Ontario tributaries during the 1983 spawning migration.

Tributary	Latitude (N) and Longitude (W)	Abundance
Spencer	43° 16′;79° 55′	6
Bronte	43° 24′;79° 43′	20–40*
Credit	43° 33′;79° 35′	7*
Bowmanville	43° 54′;78° 41′	4*
Wilmot	43° 54′;78° 36′	30–40
Ganaraska	43° 57′;78° 18′	20–40+
Shelter Valley	43° 58′;78° 00′	11+

*based on angler reports
+OMNR collections only

Five fish were captured at suitable gravel spawning sites in Spencer Creek, between 19 and 27 September 1983. A spent female was captured on a redd on the latter date. Two redds were observed with attendant females in Wilmot Creek on 23 September, whereas two pairs were reported to have spawned in Shelter Valley Creek in September 1983 (D. Bell, Ontario Ministry of Natural Resources, personal communication).

Five live eggs were retrieved from the spawning area of Spencer Creek on 15 November, however, no alevins were collected. The cultured eggs hatched between 6 November and 1 December. The resulting alevins began to swim-up on 2 February 1984 with schooling commencing on 17 February. These events agree with Kwain and Lawrie (1981), who found swim-up to occur in early spring, when the rivers were still ice covered, and fry subsequently moving out of

TABLE 2. Average fork length (cm) and live weight (g) of Pink Salmon from the lower Great Lakes during 1983.

Lake	Sex	No.	Fork Length	Standard Error	Weight	Standard Error
Huron	male	5	43.26	0.39	1133.88	55.21
	female	10	43.35	0.98	1179.36	88.93
Erie	male	8	45.35	1.89	1045.0	62.38
	female	10	41.41	1.64	757.80	1.51
Ontario	male	5	40.42	2.65	518.5	91.35
	female	8	39.28	1.08	564.47	68.27

the streams during the spring flood.

The average length-weight data for Pink Salmon from the lower Great Lakes is listed in Table 2. Fish from Lake Ontario were much smaller than those from Lake Erie, whereas the largest were from Lake Huron. However, the largest specimen in the 1983 samples was a male measuring 54 cm (1685 g), which was netted in Lake Ontario off the Welland Canal on 29 September 1983. All the fish sampled from Lakes Erie and Ontario were two years old, with no three year old or even year spawners yet reported in the lower lakes. There was very close agreement between the size of the 1979 (Kwain and Lawrie 1981) and the 1983 fish from Lake Erie. Fish from Lake Erie in 1979 averaged 42.91 cm and 877.41 g. Due to the trophic status of Lake Superior, fish from that lake were much smaller, averaging only 35.80 cm and 576.10 g (Kwain and Lawrie 1981).

The species can now be regarded as an addition to the Lake Ontario fauna. During early October 1983, water temperatures in several of the more marginally suitable streams entered were high (20° C). As this was close to the upper lethal temperature of the eggs, the number of resulting fish returning as adults in 1985 may be small. The species has yet to be confirmed in the St. Lawrence River; thus at present it is speculative that the species will successfully move downstream to salt water. The species has existed on the east coast with introduced populations present in Newfoundland streams during the 1970s (Scott and Crossman 1973). Competition with Atlantic Salmon (*Salmo salar*) should be minimal as the species spawns earlier in the fall, and does not feed in the nursery streams. In contrast, competition for rearing areas is much greater between Atlantic Salmon and the now present populations of anadromous Rainbow Trout (*S. gairdneri*) and Coho (*O. kisutch*) on the east coast (Ouelett and Côte 1977; Martin and Dadswell 1983).

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Dr. J. Kelso and R. Collins of the Great Lakes Fisheries Research Branch, Sault Ste. Marie, provided the data on the Lake Huron fish. J. K. Leslie assisted with the sampling and critically reviewed the manuscript. We would like to thank D. Reid, D. Bell and H. Gingrich of the Ontario Ministry of Natural Resources for allowing the collections and providing information from their records and collections.

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Spring Weather and Local Movements of Tree Swallows, *Tachycineta bicolor*

R. F. STOCEK

Maritime Forest Ranger School, R.R. 10, Fredericton, New Brunswick E3B 6H6

Stocek, R. F. 1986. Spring weather and local movements of Tree Swallows, *Tachycineta bicolor*. Canadian Field-Naturalist 100(1): 134–136.

Observations of Tree Swallows (*Tachycineta bicolor*) at a Fredericton, New Brunswick colony during the early part of the breeding cycle indicated that weather plays an important part in local movement of the birds. Air temperatures exerted a considerable influence up to 15°C; above that sunshine and precipitation each had a significant effect. Relative humidity, barometric pressure and wind appeared to be of minimal importance.

Key Words: Tree Swallow, *Tachycineta bicolor,* spring weather, local movement, New Brunswick.

Investigations have shown that Tree Swallows (*Tachycineta bicolor*) at a breeding colony in early spring often depart from the area during inclement weather only to return as it improves (Kuerzi 1941; Paynter 1954; Chapman 1955; Mason 1968). Supporting quantitative weather details in those studies, however, are sparse and fragmentary, leaving one to question the important weather variables prompting this swallow movement. The availability and abundance of flying invertebrates, the main food source of this species, is also influenced by a variety of weather factors (McClure 1938; Glick 1939; Wellington 1945; Williams 1961). Hence, the local movements of the birds may be a response to the availability of the food supply. This paper documents the influence of various weather factors on the presence of Tree Swallows at a colony in New Brunswick during the early part of the breeding cycle.

Methods

Tree Swallows were observed at a small nest-box colony in Fredericton, New Brunswick. The area used for nesting and feeding encompassed 4 ha, including wet meadows, mixed woods, a small conifer plantation, a major highway and a complex of buildings. Most foraging took place over the 2 ha meadow. The entire site was viewed from a vantage point 8 m above the ground.

Observations made over seven years totalled 120 days, from the time the birds arrived in mid to late April until the time of egg laying in late May-early June. Each observation period extended from 1200 to 1700 h. Notes were made on the presence or absence of swallows; rarely were there instances of only 1 or 2 birds on the area — they were either all there or all gone.

Weather data were obtained on site, from the Canadian Department of Agriculture Research Station, 5 km to the east, and from the Canada Atmospheric Environment Service at Fredericton Airport, 11 km to the southeast. The mean and total values for the five hour observation periods were determined for ambient air temperature (°C), relative humidity and wind velocity (all on site), duration of sunshine (research station), and barometric pressure and duration of precipitation (airport).

Comparisons were made using the weather elements (singly and in combination) between days when the swallows were present and days when they were absent. Calculations using contingency tables and "t"-test were considered significant at the five percent level ($P > 0.05$) and highly significant at the one percent level ($P < 0.01$).

Results and Discussion

Air temperature appeared to play a dominant role in the movement of the swallows. The means, within the observed range of 1.1° to 27.2°, were 19.7° on days when the birds were present and 11.2° when they were absent, a highly significant difference. Birds were never seen at the colony when the mean temperature dropped below 13° (Table 1), in spite of other more favourable weather elements. Within the 13°–20° range, mean temperatures were also significantly higher ($P < 0.01$) on days when birds were present. Temperature was not a controlling factor on days $> 20°$, even though birds were always present then since other weather elements assumed importance. Several authors (Kuerzi 1941; Koskimies 1950; Brown 1976; Finlay 1976) have noted that a decrease in avian activity and foraging or departure from a breeding colony was in response to temperatures below 13° and depleted food supply. The abundance of aerial insects is significantly decreased below a temperature of 13°

TABLE 1. Mean values of weather elements during days when Tree Swallows were present (P) at or absent (A) from a nesting colony in Fredericton, New Brunswick, and number of days when birds were (P) or (A) under various weather conditions. Days = observation periods.

	Total Temperature Range		Temperature Range					
			< 13°		13°–20°		> 20°	
Element	P	A	P	A	P	A	P	A
x̄ Air Temperature (°C)	19.7	11.2	-	6.7	17.3	15.1	21.7	-
x̄ Sunshine (h)	3.8	0.8	-	0.6	3.5	0.9	4.4	-
0	3	35	0	24	3	11	0	0
0.1–5.0	58	24	0	10	35	14	23	0
x̄ Precipitation (h)	0.2	2.2	-	2.3	0.3	2.1	0.0	-
0	57	23	0	15	35	8	22	0
0.5–5.0	4	36	0	19	3	17	1	0
x̄ Relative Humidity (%)	38.4	69.4	-	74	39	64	37	-
20–59	53	19	0	7	32	12	21	0
60–94	8	40	0	27	6	13	2	0
x̄ Barometric Pressure (kPa)	101.3	100.8	-	100.9	101.3	100.7	101.2	-
99.4–100.9	20	33	0	17	12	16	8	0
101.0–102.9	41	26	0	17	26	9	15	0
x̄ Wind Velocity (km/h)	19.5	19.0	-	19.0	19.5	19.0	19.5	-
0 –16.0	25	24	0	13	14	11	11	0
16.1–44.8	36	35	0	21	24	14	12	0
Number of Days	61	59	0	34	38	25	23	0

(Glick 1939) or within a small range encompassing that value (McClure 1938; Wellington 1945).

The amount of sunshine during the days when the birds were present was significantly greater ($P < 0.01$) than when the birds were absent (Table 1). However, in the lowest temperature range (< 13°) sunshine appeared to have little influence. Within the 13°–20° range, swallows were more likely ($P < 0.01$) to be present when the sun was shining, although their absence from the colony wasn't necessarily related to lack of sunshine. On days >20°, all birds were present when the sun was shining but there are no comparative data for days without sunshine. Sunshine was believed important in the departure of swallows from a colony (Kuerzi 1941) and the feeding success of swifts (Lack and Lack 1951), though other investigators (Koskimies 1950; Finlay 1976) did not think it important. However, sunshine has a stimulating effect on most insects and a decrease in flying insect activity can be expected on cloudy or overcast days (McClure 1938; Glick 1939).

Rainfall also exerted an influence on bird movement. Swallows were often absent on rainy days and the mean duration values then were also significantly higher ($P < 0.01$) (Table 1). However, it was not unusual to see the birds foraging in rain showers. The presence of rain can effectively interrupt the food supply (McClure 1938; Glick 1939) and prolonged rain combined with low temperatures can be fatal to some insectivorous birds (Koskimies 1950), or reduce their activity (Finlay 1976).

Relative humidity was significantly lower ($P < 0.01$) on the days when birds were present (Table 1). Since humidity decreased with temperature and increased with precipitation, it seems likely that any effect of that factor, per se, on swallow movement is probably coincidental, a view shared by others (Koskimies 1950; Finlay 1976). The effect of relative humidity on insect activity may be minimal (Glick 1939; Wellington 1945) or more significant (Hardy and Milne 1938; Freeman 1945).

Barometric pressure showed a weak association ($P < 0.05$) with bird presence even though the mean values were significantly different ($P < 0.01$) (Table 1). The difference shown, however, may not indicate direct influences since pressure was related to both temperature and precipitation. Finlay (1976) found no significant correlation between barometer pressure, per se, and Purple Martin (*Progne subis*) activity. Falling barometric pressure stimulates greater insect flight activity and it is the change rather than the pressure itself that the insects respond to.

Wind velocities were similar on days when birds were either present or absent (Table 1), indicating no significant association between wind and swallow movement. Wind has been reported as exerting considerable influence on aerial insect abundance (Glick 1939; Freeman 1945; Williams 1961). Some investigators (Koskimies 1950; Lack and Lack 1951; Finlay 1976) have noted an inverse relationship between wind and bird activity and foraging.

Weather elements acting in concert may be more

important in influencing swallow movements. Generally, high air temperatures, sunshine and lack of rain were associated with birds' remaining at the colony. Humidity, barometric pressure and wind, in combination with the other factors, were found to exert a negligible influence on activity. The mean temperature in the 13°–20° range on the days when the birds were absent, the sun was shining, and precipitation much below the duration mean (1/3 less), was significantly lower ($P < 0.01$) than when similar conditions existed and the birds were present. This suggests that temperature exerts an important influence on movement, but only up to about 15°. Above that the presence of sunshine and the duration of precipitation each apparently had a significant effect ($P < 0.01$) on whether or not the swallows remained in the area. Temperatures above 15° seemed to have no effect on movement on sunny days or days without rain. Others (Koskimes 1950; Finlay 1976) also noted the reduced effect of temperatures above 15° on bird activity and foraging. The lower limit for the normal appearance of flying insects is about 15° (McClure 1938; Wellington 1945; Koskimies 1950). It appears that foraging becomes less of a problem above this temperature for swallows because of the greater abundance of insects.

On four occasions in May when the birds were absent from the study area, I saw hundreds of swallows foraging over water at lower elevations some distance from the colony. Once, some were seen feeding over a river for an extended period of time in a driving rainstorm with high winds. Swallows may be attracted by greater insect activity caused by warmer temperatures over open water. It seems that the weather factors considered in this study may directly influence the availability of flying or aerial invertebrates and the swallows apparently respond in their movements to the presence or absence of this food source.

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Observations During the Stranding of One Individual from a Pod of Pilot Whales, *Globicephala melaena,* in Newfoundland

PETER J. MCLEOD

Department of Psychology, Dalhousie University, Halifax, Nova Scotia, B3H 4J1

McLeod, Peter J. 1986. Observations during the stranding of one individual from a pod of Pilot Whales, *Globicephala melaena*, in Newfoundland. Canadian Field-Naturalist 100(1): 137–139.

The behavior and vocalizations of a Pilot Whale (*Globicephala melaena*) were recorded as it broke away from a pod of ca. 60 animals and stranded on a beach in Newfoundland. Echolocation-like clicks were recorded from the individual shortly before the stranding.

Key Words: stranding, Pilot Whale, *Globicephala melaena,* echolocation, Newfoundland.

Natural strandings of long-finned Pilot Whales (*Globicephala melaena*) are common along the northwestern Atlantic coast (Geraci and St. Aubin 1975, 1977; Sergeant and Fisher 1957; Sergeant, Mansfield and Beck 1970). Despite the frequency of these events, there has been no published account of the behaviour of Pilot Whales during a natural stranding.

On 17 October 1980, a pod of approximately 60 Pilot Whales entered the harbour at Pt. Leamington on the northern coast of Newfoundland (47° 20′N, 55° 24′W) and remained there until sometime before sunrise on 24 October. During the week that the pod remained in the harbour, five individuals died along the shore. The stranding of one of these individuals was observed from a 4 m inflatable boat and is described below. All behavioral observations were recorded, by voice, on a Uher 4400 Report Stereo. Underwater sounds were recorded on a second channel using a Gould CH-17 UT hydrophone (flat frequency of the system, 20 hz to 18 kHz).

On 21 October, a 9 to 10-year-old (age determined by examination of teeth, after Sergeant 1962) lactating female Pilot Whale (length 4.14 m) was observed to break away from the pod of Pilot Whales in Pt. Leamington harbour at 1141 h. During the next four minutes the whale surfaced at a mean rate of once every 13.2 s (SD = 1.4, N = 15) while moving 150 m from the pod toward shore. Her movement away from the pod was not consistent; two surfacing instances occurred with the whale oriented back toward the pod. On these occasions when the animal was oriented toward the pod she was not swimming.

By 1155 h the whale was about 50 m from shore. At this time the animal was observed to spyhop once, with her mouth open, facing the shore where another Pilot Whale (7 year old female) was dead on the beach. At 1157 h it was apparent that the individual was about to strand as she swam within 12 m of the shoreline (Figure 1).

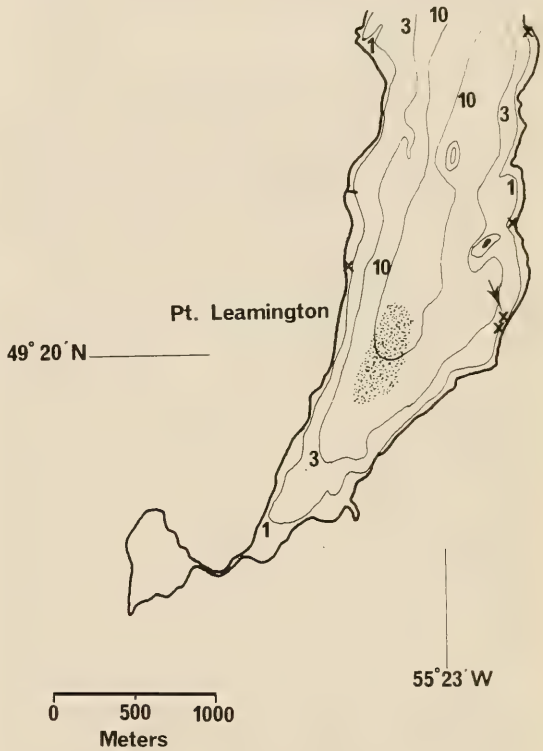

FIGURE 1. Pt. Leamington harbour at the head of the Southwest Arm of New Bay with 1, 3, and 10 fathom (1.8, 5.5, and 18 m) depth contour lines. Dappled area delimits the location of the pod during observed stranding. X - stranded individual on the shore. Arrow denotes the individual observed to strand. (Adapted from Canadian Hydrographic Services chart 4594.)

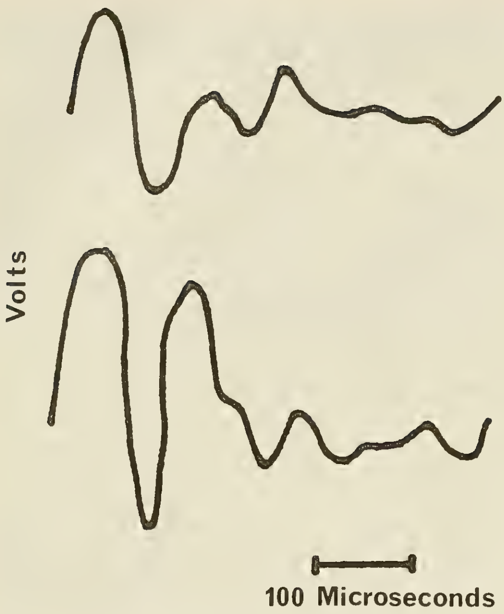

FIGURE 2. Example waveforms of echolocation-like pulses recorded from a stranding Pilot Whale within the five minute period immediately prior to beaching. Maximum energy ranged from 6 to 11 kHz (167 to 100 microseconds per cycle).

During this period (1155 to 1157 h) several echolocation-like pulses, with maximum energy between 6 and 11 kHz (Figure 2), were emitted by the stranding animal. No other sounds were recorded during the time that she was away from the pod.

By 1159 h respiration was very rapid, with blows occurring every 2.3 s (SD = 0.6, N = 7). Aground at 1204 h, the whale vigorously flailed her tail stock. By 1206 h the whale had ceased struggling and was lying on her side with the blowhole underwater. I turned her so that the blowhole remained out of the water but respiration had ceased. The animal showed no signs of life by 1215 h (no response to touching on or near the eye).

There was a gently sloping mud bottom where the whale stranded. During the stranding there were no potential predators in the area and no boats except for mine which was drifting with the motor off. Winds were from the south-west at about 15 to 20 knots (30 to 40 km/h; waves 0.5 to 0.7 m), the sky was partly-cloudy (approximately 15% cloud cover), and the tide had just started to rise when the animal stranded (low tide 1112 h).

Several aspects of this stranding are noteworthy:

1. The stranding animal emitted echolocation-like pulses shortly before becoming stranded. These pulses had maximum energy at frequencies from 6 to 11 kHz, within the range recorded from other groups of Pilot Whales (McLeod, unpublished data) and from other odontocete species (Popper 1980). Dudok van Heel (1966) has hypothesized that strandings are a result of odontocetes having trouble detecting gently sloping beaches using echolocation signals. This is most likely if the animals are paying attention to the higher frequency components of their echolocation pulses, as they are assumed to be when feeding (Dudok van Heel 1966). During the events reported here, the stranding animal was not feeding and there is no reason to assume that she did not locate the shoreline either using echoes from the lower frequency components of the pulses or from surf noise.
2. The individual did not emit any other vocalizations after splitting from the pod. This is also the only instance during hundreds of hours of observation that I observed a single Pilot Whale break away from a pod. Vocalization rates (for whistles and pulsed tones) for pods of Pilot Whales at sea average one per individual per minute and can reach at least five per individual per minute (McLeod 1982). Other individuals caught in fishing gear or singly stranded have also been silent although vocalizations were recorded from two immature members of a mass stranded pod of Pilot Whales (McLeod 1982). Caldwell, Caldwell and Walker (1970) reported that no vocalizations were heard from a group of 150 to 175 False Killer Whales (*Pseudorca crassidens*) stranded in Florida, nor were any recorded from a female individual of that herd kept in captivity for a further two days. Single stranded immature Dense-Beaked Whales (*Mesoplodon densirostris*) and Black Right Whales (*Balaena glacialis*) have vocalized (Caldwell and Caldwell 1971).
3. Respiration rate increased five-fold from less than five to 26 per minute within 20 minutes of the stranding animal leaving the pod. Cowan (1966) has similarly reported an increase in respiration rate from one to 12 per minute for a wounded 12 year old male Pilot Whale (*G. melaena*) held in shallow water during a whale drive in Newfoundland. Single stranded whales often have respiratory infections involving difficulty in breathing (Ray 1961). However, inspiratory rales, which often accompany pneumonia in cetaceans (Sweeny and Geraci 1979) were not heard from the stranded whale. A necropsy was not performed on this animal.
4. The individual died within 30 minutes of breaking away from the pod. Mass stranded Pilot Whales

have lived for over 36 h. This animal had no external wounds nor was she excessively old.

5. The stranding animal's movement toward the shore was slow with no signs of "panic". (The observed increase in respiration rate could, however, be interpreted as a sign of distress). Similar comments have been made by Fehring and Wells (1976) regarding a mass stranding of Short-finned Pilot Whales (*G. macrorhyncha*in Florida.
6. Sixty-seven mass stranded Pilot Whales were discovered on 19 October in a small cove three kilometers from Pt. Leamington. It is not known if these 67 mass-stranded, ca. 60 non-stranding, and 5 individually stranded whales were once members of one large pod.

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News and Comment

The "One Hundredth" Volume of *The Canadian Field-Naturalist*

Although this issue is designated as initiating volume 100 of *The Canadian Field-Naturalist*, it actually marks neither the centenary of publications by the Ottawa Field Naturalists' Club nor 100 volumes under this journal name. Nonetheless, it does mark a significant milestone in the publication's history.

The Club itself was begun 107 years ago and its first publication, number 1 of *The Transactions of the Ottawa Field-Naturalists' Club*, was issued in 1880. The latter, which contained largely reports of the Club business and the papers presented at monthly "Soirees", continued annually for seven years. Number 5 inaugurated the second volume. In 1887 the Club changed from an annual publication to a monthly one, retitled it volume 1 of *The Ottawa Naturalist*, but inserted a subtitle indicating it was continuous with the *Transactions* as number 3 of the latter. (This notation continued through subsequent volumes up to and including the first under the present journal name). In 1918 the size of the journal was enlarged and the national scope of the contents emphasized, though the change from a purely local content had actually come as early as volume 3 of *The Ottawa Naturalist* on a motion passed at the 1889 annual meeting [3(1):11]. In 1919, beginning with volume 33, the name *The Canadian Field-Naturalist* was first used. The present issue, therefore, begins the 68th volume under this name but is also the first issue of the 102nd volume of *The Transactions of the Ottawa Field-Naturalists' Club*, and the 107th year of continuous publication.

Several important special contributions documenting the journal have appeared. In 1954 J. W. Cody and B. Boivin presented an analysis, "The Canadian Field-Naturalist and its predecessors" (*Canadian Field-Naturalist* 68(3): 127–132), giving numbering and publication dates from 1880 to 1953. They followed in 1955 with "Bibliographic survey of James Fletcher's Flora Ottawaensis" (*Canadian Field-Naturalist* 69(1): 79–82), a series that had been issued as part of the journal but often paginated separately. An important contribution sponsored by the Club as Special Publication Number 2 is the *Transactions of The Ottawa Field-Naturalists' Club and The Ottawa Naturalist — Index* by John M. Gillett (1980). Another valuable compendium, produced by A. LaRoque in 1931 ("List of original descriptions published by the Ottawa Field-Naturalists' Club" *Canadian Field-Naturalist* 45(9): 214–222), cites 415 original descriptions appearing between 1880 and 1931. Dan Brunton has recently compiled this data for 1932 to 1985 and it will appear in a forthcoming issue. In 1981 Roger Taylor concluded, in a thought-provoking analysis demonstrating a time-lag in citation of papers in field biology relative to other research areas, that the contribution of *The Canadian Field-Naturalist* to the scientific literature was important ("Is the impact factor a meaningful index for the ranking of scientific research journals?" *Canadian Field-Naturalist* 95(3): 236–240).

The Editor has always had a major role in setting the standards and style of the journal. In 1982 ("Editor's Report for 1981" *Canadian Field-Naturalist* 96(2): 220–223) I listed the 17 editors who have served since the first volume of *The Ottawa Naturalist*. A system of manuscript review dates from the inception of Club publications. Since 1887 the Editor has been successively assisted by a "Publishing Committee", later "Sub-editors", and then "Assistant Editors". The term "Associate Editor" replaced these in 1885 [9(1)] and has continued in use ever since. Under whatever title was current these have always been listed in each issue of the journal.

The modern era of *The Canadian Field-Naturalist* as we know it began with Harold A. Senn who was with the Department of Agriculture from 1938 to 1960, first with the Botany and Plant Pathology Division and later as the first director of the Plant Research Institute. His thirteen and a quarter years (1941-1955) as Editor is the longest tenure in the history of the journal. It was Senn who initiated a more scientific format for the cover beginning with volume 59 (1945) replacing the charming woodcut in use since 1918 by the table of contents. It was also during Senn's editorship that the position of Business Manager was created (1948) and filled by William J. Cody. The journal has never needed another, as Bill has handled its business affairs ever since, first inclusive of all Club operations and later, after a reorganization in the 1970s, for the journal only. That he has worked so well with a succession of editors, each with very different styles, talents and objectives, demonstrates his major role and his importance to the journal's operations during the 38 years and counting he has served.

The first of the editors that I knew personally was Robert A. Hamilton (1956-1961). Bob was a professional editor with the Department of Agriculture, and took over when Senn, overburdened with administrative duties, reluctantly passed on the editing chore with the journal a good year behind in

publication. Deeply philosophic and considerate of authors, Bob made a number of changes, including the cover colour from yellow to brown (a good earthy hue, attractive to him as an amateur horticulturalist as a symbol of nature). More sweeping in its impact was the quick and quiet restoration of the publication's schedule, the redesign of its layout, the strengthening of editorial practices, and a new submission standardization through an "Advice to Contributors" notice which first appeared on the inside back cover of volume 70, number 1. Later improvements and growth in the journal clearly built on the revitalization he began, though this has been scarcely acknowledged until now.

Ted Mosquin (1967-1972) was a youthful and talented botanical research scientist with the Department of Agriculture, galvanized by an awareness of the increasing human impact on a shrinking natural environment. He superimposed this concern on the existing publication through feature editorials, a news and comment section, and active solicitation of topical environmental manuscripts, eventually changing the face of the journal with a new size and a cover photograph. Ted's editorial initiation was "The new natural history" (*Canadian Field-Naturalist* 81(2): 79–80), which emphasized the need for a new focus on the effects and rate of environmental degradation. When he introduced the "new look" in 1970 he wrote an "Editorial Policy" (*Canadian Field-Naturalist* 84(1): 3) in which he envisioned the journal's becoming a Canadian version of *Science* or *Nature*. Within the next year he had moved to the founding of the Canadian Nature Federation out of the Canadian Audubon Society (*Canadian Field-Naturalist* 85(4): 283–284) and the inauguration of *Nature Canada* to replace *Canadian Audubon*. In 1972 Ted's growing commitments as President and Editor with the Canadian Nature Federation led him to relinquish the editorial chores of *The Canadian Field-Naturalist*.

In 1967, as the Mosquin era began, the Club also expanded its publishing to initiate a journal with a focus on local natural history. *Trail & Landscape*, first under the editorship of Anne Hanes and subsequently Joyce Reddoch, has admirably filled this role. Its distribution was mainly to local members and *The Canadian Field-Naturalist* retained its status as the official Club publication.

Enter Lorraine C. Smith (1972-1981). Lorraine was a superb organizer, manager and editor. She cared deeply about quality and policy. Among her personal contribution of editorials, comments and reports totalling roughly 50 published pages during her nine-year tenure are at least three than can be read and re-read to-day with benefit by potential authors, reviewers and editors alike: "Communication via scientific writing" in 1976 (*Canadian Field-Naturalist* 90(2): 101–102), "Note to authors and referees" in 1977 (*Canadian Field-Naturalist*– 91(1): 101), and "Editorial Policy" also in 1977 (*Canadian Field-Naturalist* 91(2): 117–121). The journal under Lorraine retained the Assistant to the Editor and Book Review Editor positions that Ted had begun and added a Copy Editor and Production Manager as the number of manuscripts submitted and pages published continued to increase. The review process now almost invariably included at least one, and sometimes more, outside reviewers besides the associate editors. Changes in format occurred, among which were the treatment of notes which were now formatted the same as articles and included abstracts. Submissions became more concise and the journal reached toward a high scientific level. Lorraine also introduced separate Editor's Reports, independent of the annual Publication Committee summary. She inaugurated *The Biological Flora of Canada* series, edited by George LaRoi. Most of her innovations in editorial policy and journal format are still followed. Some time before her retirement as Editor of *The Canadian Field-Naturalist* her demonstrated skills had already been recognized by her appointment to a full time editorial position with the federal Department of Fisheries and Oceans.

On broader policy matters, particularly the support of the journal itself, she began in 1973 with "Let's consider The Canadian Field-Naturalist (*Canadian Field-Naturalist* 87(4): 343–344) and "Looking ahead" in 1975, the latter co-authored with Donald A. Smith (*Canadian Field-Naturalist* 89(1): 1–4). These focused on problems concerning the financing of the journal. In 1979 she re-examined the question and the historic importance of the relationship between the Club and the journal ("Status quo or new direction?" *Canadian Field-Naturalist* 93(1): 10–15). Finally in 1981, "Editor's farewell musings" (*Canadian Field-Naturalist* 95(3): 233–235) questioned the advisability of leaving the journal in the Club's care.

There was a vital response to these questions from throughout the Club, and many members and journal subscribers contributed substantially. The ultimate result, "A publication policy for the Ottawa Field-Naturalists' Club", was subsequently printed in 1983 (*The Canadian Field-Naturalist* 97(2): 231–234). This stresses the importance and unique niche of *The Canadian Field-Naturalist* in publishing original, refereed research and observations on current natural history of northern North America by both professionals and amateurs. It also sets formal standards for *The Canadian Field-Naturalist*, its Editor and associate editors much at the levels that Lorraine had followed. Equally important, it affirms the Club and journal's inseparability with the terse but

emphatic "The Ottawa Field-Naturalists' Club will continue to publish *The Canadian Field-Naturalist*."

FRANCIS R. COOK
Editor 1962-1966, 1981-

Editor's Note

The Publications Committee first requested this centennial review. Ron Bedford, Bill Gummer, Joyce Reddoch, Bill Cody, Dan Brunton and Elizabeth Morton commented on earlier drafts, and my thanks are due to all. Dan also corrected some historical details and added others from his original research into the minutes of the Council now in the National Archives and his detailed examination of past volumes of the Club publications. Some of his material that could not be included here will appear later in *The Canadian Field-Naturalist*.

FRANCIS R. COOK

Book Reviews

Zoology

Sea of Slaughter

By Farley Mowat. 1984. McClelland and Stewart, Toronto. 438 pp. $24.95 (20% off to members of Canadian Conservation groups).

Farley's story is packed with interesting facts. The trouble is, many of them don't hold up to critical scrutiny. Moreover they become less factual the closer one comes to the present time, which is strange, since there are surely more modern than ancient sources available to him. As far as history goes, all seems plain sailing. My criticisms are devoted principally to the second part of the book, on the killing of seals and whales, partly because there seem to be more outrageous statements there than elsewhere, and partly because it is my own subject.

I liked Farley's reconstruction of the ranges of some of the land mammals of eastern North America at the onset of European colonization — Bison, Grizzly and Polar bears, Sea Mink and the like (I have checked him out to be sure!). Here is one example where historical research and some imagination have added to what the more prosaic professional biologists tell us. But elsewhere his imagination carries him away.

Farley's chief fault is sheer exaggeration. Analysis by Mr. K. Radway Allen (*in litt.*) of Farley's earlier book *A Whale for the Killing* showed that he inflated primeval numbers of some whale species by as much as 10 times. In the present book he does the same thing for Atlantic Walrus, for example. Since he also minimises present populations (of extant species or stocks) the effect is usually to tilt the whole curve of decrease more steeply. The effect on the unsophisticated reader is to give the impression of sixteenth century seas soupy with fish, crawling with seals and whales, and blackened with flocks of seabirds, though it is a bit hard to imagine where the required primary production came from.

In any case direct exploitation of these land and sea mammals and birds is surely now a dead issue, all of them, or their survivors, being protected from hunting in our more advanced western world. And if the population at large doesn't yet know the sad history of the Great Auk et al., readers of this journal surely do.

Farley isn't an accurate reporter. He claims (p. 293) that Smallwood brought mink ranchers to Newfoundland, looked about for a source of mink food, that the South Dildo whaling station then began to hunt Pilot Whales, and that research on these animals was then started by Farley's bugbear, the Federal Department of Fisheries. Wrong! The driving of pilot whales for oil had been practised traditionally by Newfoundland fishermen. The whalers started to drive Pilot Whales in 1950 using shepherd-dog techniques, passing them over to the fishermen when they reached the inner bays. The meat was sold to mink ranches in Ontario. I started work on the biology of the whales in October 1951. Smallwood brought out some mainland ranchers in late August 1954. There hadn't been any potheads for some weeks but on the day the ranchers arrived a drive of 200 took place. This was called "The Miracle of the Potheads" by Harold Horwood writing for the St. John's *Evening Telegram*. After that, several large-scale ranchers moved to eastern Newfoundland, teaching Newfoundlanders their skills, and staying till world prices for mink dropped to a level that made ranching uneconomic. There is an interesting corollary. In 1972 the Department of Fisheries banned all whale-killing in eastern Canada. The Pilot Whale hunt had in fact died out about 1969 for want of animals coming inshore. But by 1975 the Pilot Whale population was on its way back, aided perhaps by immigration from wider seas. A herd stranded itself, this time at Southern Bay, Bonavista Bay. This town had been a centre of the drive-in hunts. Now, however, the fishermen pulled the live Pilot Whales free of the mud and out to sea. This story I think offsets the loutish behaviour of the men at Burgeo in 1967 who killed a Fin Whale with bullets, as told in Farley's *A Whale for the Killing*. Perhaps a whole climate of behaviour had changed.

Farley suggests (p. 347) that one patch of Harp Seals off Newfoundland in 1844 contained 5 million animals, and on p. 371 that the western or Canadian herd once contained as many as 10 million. The assertion of 10 million was first made by Dr. Bernhard Grzimek, a German zoo director and encyclopedist who had not himself made a special study of seals. It has been copied slavishly by all anti-sealing writers. However the original statement by Professor S. V Dorofeev of the Soviet Union in 1947, translated into English and published again by my Station, was that at least two (the western and eastern) of the three North Atlantic herds probably each numbered originally about 3 to 4 million. At present the western herd probably numbers about 2 million, the eastern herd

certainly over a million (I have no very recent data), and only the central herd a few hundred thousand. Canadian conservation in the late 1960's consisted first of protecting the adult females at the whelping patches, then setting a closing date to protect moulting adult females, and last in 1972 a quota which reduced catches to little more than half of what they had been previously. There was an immediate surge in the survival of young seals, such that the population was increasing rapidly within one seal generation of five years, in 1976.

On p. 386 Farley quotes with approval the criticisms of "two of the department's own senior research scientists, Dr. W. D. Bowen and Dr. D. E. Sergeant". He fails to note on the next page that the ironically named "department's creative statisticians" who estimated the production of young Harp Seals as nearly half a million annually were the same two gentlemen. You may read our technical publication if you wish; it is based on capture-recapture tagging of large numbers of young seals at the icefields done in 1978 to 1980. (Canadian Journal of Fisheries and Aquatic Sciences 40: 728–742).

Perhaps the great Counting House on the Lake and its further exurbs are just too far from salt waters for its inhabitants to be expected to know much about sea animals. Here in Montreal we do a little better, Terre des Hommes being visited every summer by one or two young Hooded Seals, while an occasional Finback or Minke whale from the Gulf gets wrapped around the bulbous bow of a freighter and carried up to Montreal docks. And recently, many Montrealers have gone down to the estuary and gulf to see the populations of Finback and Minke whales and Harbour Porpoises and even the great Blue Whales, which support a thriving whale-watching trade that Farley doesn't seem to have heard about.

One can, in the end, only quote Thomas Henry Huxley's indictment of Bishop Wilberforce: "a man of restless and versatile intellect, who, not content with equivocal success in his own sphere of activity, plunges into scientific questions with which he has no real acquaintance, only to obscure them by an aimless rhetoric, and distract the attention of his hearers from the real point at issue by eloquent digressions and skilled appeals to ... prejudice". To Farley Mowat's readers, I add the warning of Mark Twain, that it is not what a man don't know that hurts him, but what he knows that ain't so.

DAVID SERGEANT

Canada, Department of Fisheries and Oceans, Arctic Biological Station, Ste. Anne de Bellevue, Québec H9X 3R4

Principles of Wildlife Management

By J. A. Bailey. 1984. John Wiley and Sons, New York. x + 373 pp., illus. U.S. $26.95.

This book was written as a textbook for a university level course in wildlife biology and management. Surprisingly, there are few books for this purpose and no new ones within the past decade. As such, this volume was overdue and needed if only to incorporate recent thought into older premises.

There are five parts, each composed of several chapters: an initial short section of 50 pages which discusses, in a philosophical manner, wildlife conservation and the value of wildlife; a section on wildlife biology; and others on ecology, population dynamics and wildlife management. At the end of each chapter the author lists a number of principles which essentially summarize the most important facts presented. These are valuable additions because they will enable teachers to stress key points and students to quickly determine what each chapter covers. The literature cited section contains some 360 citations. This is poor for a book of this magnitude and a quick scan reveals few contemporary references. Therein lies one drawback of this book. Some important theories which form the basis of many recent investigations have been omitted, including kin theory (Maynard-Smith 1964; von Schantz 1984), energetics (eg. French et al. 1976), indices of diversity (Routledge 1980), indices of preference (Johnson 1980) and optimality (Krebs 1978).

The first three chapters in part 1 form an excellent discussion of resource conservation, including a large dose of original thought which will help many readers to crystallize their own views on the importance of conservation. Bailey espouses a realistic approach to wildlife management including multiple use of resources and learning from our past mistakes. He presents a cogent argument that the pro- and anti-hunting lobbies are wasting their collective energies while species continue to go extinct or at least have their populations severely eroded.

Part 2, wildlife biology, looks at soils, food, cover, movements, reproduction, behaviour, physiology and mortality. It is encouraging to see an entire chapter devoted to soils as this component is so often ignored in explanations of distribution and abundance of animals. Each chapter includes illustrative examples

taken from the literature as a means to help the reader understand the principle discussed. Unfortunately I found some of these chapters, particularly the one on food, to be so full of facts as to become tedious. The author's definition of cover is "any structural resource of the environment that enhances reproduction and/or survival of animals by providing for any of the natural function of the species". This seems rather too expansive and might even refer to an animal's habitat. Cover is a difficult concept to define at the best of times since most biologists equate cover with shelter. For example, some may disagree that cliffs represent "escape cover" for big-horn sheep.

Among the chapters in part 2, by far the best is the one on wildlife mortality. Concepts of density dependence, density independence, compensatory and additive mortalities, harvestable surplus and the role of predators are all explained clearly and students will have no trouble understanding these important ideas. Predation is treated in a particularly articulate manner.

Part 3, wildlife ecology, comprises chapters on habitat, succession and weather. Extensive use is made of Leopold's (1933) three productivity factors (welfare, decimating and environmental). I felt this clouded this complex subject because the author spent much time defining each and their components rather than examining habitat through a more holistic approach.

Although lacking in mathematical treatment of population dynamics similar to that in Wilson and Bossert (1971), the three chapters on this subject in part 4 present a solid introduction. Included are discussions of the sigmoid model, carrying capacity, biotic potential, time lags, stability, and cyclic and eruptive populations. These chapters are lucid and well written, dealing with a series of difficult subjects in an admirable manner.

The final two chapters of part 5, wildlife management, introduce a few types of measurements performed by wildlife managers (King census, population condition indices, habitat condition indices) and then present steps in the wildlife management process. Bailey states that wildlife management is an art and not a science, where biological and ecological knowledge is applied to achieve goals. He rightfully acknowledges that a manager must often act based on limited information and his or her own 'gut feelings'. Equally correct is his assertion that good wildlife research often has little application because questions important to the manager were not asked.

This book has several strengths and weaknesses. I feel it relies too heavily on an old-school approach to wildlife management as advocated by Leopold (1933) and King (1941), while omitting several recent important contributions including most publications after 1975. As well there is essentially no mathematical treatment of key population models and only a few examples of statistics used in developing various indices. Use of age and sex data in management is omitted.

The philosophical discussions of the value of wildlife are well-written and sections on mortality, population dynamics and succession make the book a worthwhile addition to a biologist's library, particularly for those involved in education. This book is not a substitute for *Wildlife Management Techniques Manual* (Schemnitz 1980). For actual field techniques that volume is still required. Bailey does not tell us how to manage wildlife populations, but tries to point out what one must consider in attempting to achieve a management goal, and complements this aim through a treatment of principles.

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I. D. THOMPSON

Canadian Forestry Service
Box 6028, St. John's, Newfoundland, A1C 5X8

Fishes of Pennsylvania and the Northeastern United States

By Edwin L. Cooper. 1983. The Pennsylvania State University Press, University Park. vii + 243pp., illus. U.S. $27.50.

This book comprises short introductory sections covering geology and climate (3 pages), origin and dispersal of fishes (5), list of fishes (3), glossary (3), and a key to families (5). Accounts of 196 species follow (189 pages) with a literature cited section of 978 items and an index. It is of interest to Canadian biologists as a summary indicator of the ichthyofauna of a state neighbouring Ontario.

The title is something of a misnomer since the book concerns itself with fishes from Pennsylvania and not the whole northeastern U.S.A. The introductory sections are short and interesting but wet the appetite for more. The species accounts have brief family descriptions, keys to genera, generic characters, and keys to species. Many of the key characters are illustrated, always useful for unfamiliar features, although some diagrams are not clear and would have benefited from arrows or lines to point out the particular aspect of the character. In the key to minnows, it is admitted that 10 or more fish may have to be examined to confirm the presence of the diagnostic flap-like barbel in Pearl Dace, *Semotilus margarita*, or the key leads one astray. Never collect less than 10 putative Pearl Dace! The absence of this character often frustrates users new to these fishes; an alternative means of separating *Semotilus* species later in the key is essential.

Each species account has an illustration of the fish under its scientific and common names, sections on distribution, behaviour, food, and value, and a spot distribution map. Each of the narrative sections is short. The illustrations vary considerably in type and quality. Most are black-and-white photographs of preserved specimens and some are line drawings. Not all the fish used in these illustrations are from Pennsylvania. The photograph of a Silver Lamprey is from an Ohio specimen which at some point lost its tail. A better specimen could surely have been chosen! The maps are small and the spots minute. Each species distribution map is divided by four lines into Great Lakes, Ohio, Susquehanna, Potomac and Delaware drainages but no rivers or lakes are marked. It is necessary to refer to a stream system map in the introductory section. There is a loss of data here in that one cannot, for example, relate spots to stream size, population centres, areas rich in lakes, or roads (the latter reflecting easy collecting access). It isn't possible to locate precisely the distribution record. Nevertheless the maps are useful since recent collections are separated by symbols from older collections recorded in the literature. This distributional data and the keys are the most important contributions of the book.

There are no descriptions of the fishes, other than of characters found in the keys and the generic accounts. Readers who care to back-track will find that the Creek Chub has fewer than 11 soft dorsal fin rays and more than 52 lateral line scales but there is no original nor compiled data on countable or measurable characters. Identifications cannot be checked by additional characters (very useful in Creek Chub, one of the infamous *Semotilus*!) and the Pennsylvania populations cannot be compared with others.

Cooper records the extinction of 27 species from the ichthyofauna of Pennsylvania, a shocking figure due mostly to pollution, and a salutary warning to Ontario.

The book is a most useful introduction, at a moderate price, to the fishes of Pennsylvania, their distribution and how to identify them. Those readers with some knowledge of fishes will benefit more than newcomers to the field who would have been better served by a more extensive and descriptive work.

BRIAN W. COAD

Ichthyology Section, National Museum of Natural Sciences, Ottawa, Ontario K1A 0M8

Butterflies East of the Great Plains: An Illustrated Natural History

By P. A. Opler and G. O. Krizek. 1984. Johns Hopkins University Press, Baltimore. xvii + 294 pp., illus. U.S. $49.50.

This is a marvelous book. The authors and the publisher should be proud of a fine effort in producing an informative, accurate, and well illustrated volume in a field where one might well be tempted to say, "Not *another* butterfly book!" What sets this one apart from other butterfly books of recent years is its emphasis on butterflies as organisms rather than as specimens. The first section, 34 pages long, is entitled "The Study of Butterflies." It is a very good summary of the present state of knowledge concerning virtually all aspects of butterfly biology, including systematics, morphology, distribution, behavior, life history, procedures for making studies, and more. The information is presented in a well written and easy to read

fashion, and is accompanied by clear, helpful line drawings, graphs, and tables. This section should provide the amateur and professional entomologist alike with many ideas for interesting and feasible observations and studies that can be undertaken even with limited resources. The bulk of the book is composed of individual accounts of virtually all the species that occur in the United States east of the Great Plains. For the purposes of the authors this means the area from the Canadian border to Key West, Florida, and from the states along the western banks of the Mississippi River to the Atlantic Ocean. Each species account, except for a few uncommon or poorly known species, is organized into several parts. First comes an etymology (derivation of the scientific name), and then a brief synopsis concerning significant, distinctive, or unusual features of the species' biology, distribution, or point of origin. Next there is a description of the adult butterfly, including the sizes of both sexes, distinctive markings, sexual dimorphism, seasonal polymorphism, and geographic variation. This is followed by a description of the species' range, including in most cases a plot of the range on an outline map of the eastern U.S., and a summary of the habitat of the insect. The section on life history is subdivided into separate paragraphs dealing with behavior, broods, and early stages. The final two sections are adult nectar plants and caterpillar host plants. The authors have taken the time to verify to a considerable extent the records in these sections, with the result that the information can be considered authoritative. In the centre of the book are 324 color photographs on 54 plates illustrating almost all of the species discussed in the text. The photographs are of butterflies in nature, and the majority are excellent. The first six illustrate typical caterpillars, but the rest are of adults resting, feeding, mating, puddling, or engaging in other activity. Males and females are shown for many species, as are both the upper and lower wing patterns where these differ, as well as seasonal and mimetic forms. At the end of the species accounts are a list of species of doubtful occurrence in the eastern U.S., a glossary of technical terms, a six page bibliography of scientific papers on butterflies to permit a rapid introduction to the specialized literature, an index of scientific and common butterfly names, and an index of scientific and common nectar source and plant names.

Opler and Krizek have opted for the classification and nomenclature of Howe (1974) rather than the more recent (and, to their way of thinking, radical) classification of Miller and Brown (1981). In a book of this sort, designed for a readership composed in large part of amateurs with no training in systematics, this might seem the better course, but it has the effect of continuing to foster an artificial classification based almost exclusively on North American species with little or no regard for relationships to the world fauna. Readers interested in pursuing this question further may begin with Johnson and Quinter (1984) and the references therein.

I am aware of very few errors of fact in the text. One, however, occurs in the discussion of classification and names on page 7. The authors are incorrect in saying that validly described species must have a type species and a type location; these are not required under the Code of Zoological Nomenclature. Another error is the use of hyphenated names (as in *Nymphalis vau-album*); this is not permitted under the Code. But these are trivial problems that scarcely detract from the very high quality of the book as a whole. A potentially more difficult problem for readers of the Canadian Field-Naturalist is the restriction of coverage to the United States. However, this really amounts to only a minor annoyance — range maps that do not include Canada being the most severe problem.

This is a very well written and beautifully illustrated book. It is well designed and produced. I highly recommend it as a reference for anyone with an interest in butterflies, or as a coffee table book for nature lovers in general.

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CHARLES R. PARKER

8256 Getty Court, Springfield, Virginia 22153

The Ecology of Aquatic Insects

Edited by V. H. Resh and D. M. Rosenberg. 1984. Praeger Publishers, Toronto and New York. U.S. $35.

This new volume is the first attempt in nearly 15 years to treat the ecology of aquatic insects in a detailed, comprehensive text. Most recent books on aquatic entomology have dealt with biology and ecology on a systematic level, usually as short notes in addition to keys, or as descriptions of a single group of insects. At best some basic ecological principles have been addressed in introductory chapters in these taxonomic works. The present volume, however, deals with aquatic insects from quite a different perspective: representative insects are considered only as examples of the broader ecological principles. The result is more a compilation of the present knowledge of various trends and processes of insects in aquatic habitats, and less a discussion of the insect species themselves.

A total of 17 different chapters by 22 authors covers a surprisingly wide range of subjects, dealing with topics such as Aquatic Insects as Primary Consumers; Secondary Production; Colonization Dynamics; and even the effects of Fish Predation on Aquatic Insects. A basic bias running through much of the book is the strong orientation to flowing water ecosystems. The ecology of lake benthos is often treated in limnology texts, so this bias is perhaps understandable. However, some of the processes described are more completely known from limnological studies than from stream studies.

In almost all cases the discussion of each subject covers a broad range of opinion, and the contributors have been well chosen for their presentation of sometimes conflicting theories. Much of this information is very recent and the authors of each chapter have gone to great length to emphasize the present work in their fields. This text is highlighted by examples drawn not only from the northern hemisphere but includes examples from all over the world. Extensive use has been made of tables to deal with species-specific information with the quite positive effect that the text itself is not cluttered with myriad examples.

Due to the broad nature of the subjects covered in each chapter, no one area is treated in very great depth (most chapters are about 20 text pages in length) and specialists find their own area of interest treated in less detail than they would want. In some cases the author has been quite selective, and has included only subjects for which recent information is available. However, as compensation, each chapter does include an extensive bibliography for those requiring greater detail.

The basics of aquatic insect ecology (and biology) are nevertheless well treated, and these chapters comprise almost one half of the book. This volume is unique in its inclusion of other subjects seldom considered. Included in the second half, for example, are chapters on Hydrologic Determinants of Aquatic Insect Habitats; Insects of Extremely Small and Extremely Large Aquatic Habitats; The Hyporheic Zone as a Habitat; and even a chapter detailing some of the principles of Hypothesis Testing in Ecological Studies. Few of these subjects have been treated in texts on aquatic entomology before, and the present volume represents a recent and very broad overview of aquatic insect ecology.

Finally, something must be said of the editing. Unlike many texts composed of papers by different authors, a continuity runs through the book that is usually found only in single-author texts. This reviewer found it a pleasure to read, an assessment extending even to those chapters that might otherwise have been tedious in their familiarity.

It is refreshing to finally have a book devoted in its entirety to the ecology of aquatic insects — one that explores the subject from its basic principles. Much has happened in the area of aquatic insect research in the last 10 years, and the present volume makes a very good attempt to consider most of it. This volume is a timely compilation of recent knowledge that would not be out of place in anyone's library.

REIN JAAGUMAGI

Department of Entomology, Royal Ontario Museum, 100 Queen's Park Crescent, Toronto, Ontario M5S 2C6

Polar Bear — Life History and Known Distribution of Polar Bear in the Northwest Territories up to 1981

By D. R. Urquhart and R. E. Schweinsburg. 1984. Government of Northwest Territories, Yellowknife. 69pp., illus. $6.00.

The remote icy fastness of the far North has long held a fascination on the minds of explorers, naturalists, entrepreneurs, and industrialists. Early European adventurers often foundered in the harshness of this world, while today's eminent technologists delve into its resource riches. Too little is known to adequately assess development's biological impact, the lament of many biologists and conservationists in the latter years of the twentieth century. An underlying motif in Urquhart and Schweinsburg's short essay is that of industrial development in the Arctic, current and proposed.

The Polar Bear is, for many, symbolic of the Arctic — aloof, beautiful, and potentially dangerous. Polar bears are not an unreasonable choice of symbol with their circumpolar distribution, contiguous with the sea-ice. Five nations lay claim to the world of the Polar Bear — Canada, Denmark, Norway, U.S.A., and U.S.S.R. — and are responsible for its future well-being. Legislators and scientists of those nations have been able to draft treaties that enable close cooperation in the monitoring and management of that symbolic animal. It is noteworthy that no other treaty is in effect between those five nations.

Sound management must be based upon sound knowledge. The authors have amassed a great deal of biological information that previously had only been available in unpublished government reports. Fully 75% of the citations are from this "grey literature" or from popular books and articles which are not subject to peer review. The most current reference is from 1981. Here we have a brief account of the natural history of polar bears and an overview of their population dynamics, distribution, and movements within the Northwest Territories, home to perhaps one-half of the world's total. Results and conclusions are reviewed by management zone, regions approximating the limits of discrete populations. Well written and informative, the book suffers from only a few typographic and layout errors. For example, the first figure has merged Devon and Ellesmere Islands and has moved Polaris Mine from Little Cornwallis Island to Cornwallis Island. Standard deviation and standard error appear to be used interchangeably throughout the text.

There are problems associated with a work based upon so much nonreviewed literature, and without the relevant documents in hand it is difficult to assess whether all data are of equal worth and whether the conclusions drawn are reasonable. Commendably, the authors stress caution when interpreting the data presented. The database is still sparse and much current work is ongoing to try to fill in the gaps. However, some questions will not be soon answered. Problems confronting biologists attempting to gather information on Polar Bears are daunting. Populations are scattered over vast areas at low densities, the climate is generally harsh, the weather often capricious, and the operating costs are high. Sample sizes are perforce small. Studying the population ecology of such a large mammal is still more art than science.

Although slanted toward the needs of the wildlife manager with emphasis on population discreteness and regional harvest intensity, this is the best account currently available on Polar Bears for the general reader.

MALCOLM A. RAMSAY

Department of Zoology, The University of Alberta, Edmonton, Alberta T6G 2E9

Johann Friedrich von Brandt: Icones Avium Rossico-Americanarum, Tabulae VII, Ineditae. With Comments on Birds, Expeditions and People Involved

By Bernt Loppenthin. 1984. Scandinavian Fine Editions, Copenhagen. 85 pp., illus. Danish kroner 385.

Loppenthin has located and reproduced an interesting series of seven plates of 49 birds from what is now Alaska. Lithographed by W.G. Pape in the 1830s, printed but not formally published, a set turned up in Denmark after 90 years of oblivion. Charles Lucien Bonaparte had access to a set for his 1857 list but his citations were inconsistent and confusing.

Loppenthin's careful study of the relevant literature in other languages, chiefly German, provides a real service for English-speaking naturalists and historians. He cites recent Russian references to Murrelet nesting that preceded those published in North America. His studies of geography and history, as well as ornithology, have allowed him to correct errors and misconceptions in the literature. Nevertheless, for some species he has had to resort to speculation and educated guesses. He provides a nice review of the

early Alaskan expeditions and the accomplishments of their German, Russian, and Danish surgeon-naturalists who preceded their British and American counterparts.

The paintings themselves, the rather stilted stereotypes of their time, are more of historical than of artistic interest. In seven instances the portrait is of the type specimen from which the initial Latin description was made. The somewhat oversized pages were made necessary by the size of the original plates which were copied.

The 1836 map of the North Pacific, of historic interest, should have been accompanied by a modern map showing all of the place names mentioned in the text.

The book, written from a North American viewpoint, would have benefitted from consultation with a North American reviewer prior to publication. Since it deals mainly with specimens from northwest North America, Loppenthin might better have used the AOU Checklist as his standard, listing the type localities for each taxa as cited by the AOU. The European convention of shortening names of describers is unfamiliar to the North American reader: Bon stands for Bonaparte and Gml for Gmelin while Br stands for Brandt, not Bruch. There are some spelling inconsistencies between the text and the bibliography.

The species accounts list the Latin names given by Brandt and Hartlaub to the birds in the first known set of unpublished paintings, as well as the names notated by Voznesenski and Eschricht on a second set. Citations in published accounts then follow. This mixture of published and unpublished citations for each species might prove confusing to any casual researcher who consults the species description without reading the preliminary material. Written somewhat ponderously in English by a Danish scientist, careful collation between several portions of the book proves necessary.

This worthwhile but specialized contribution is appropriate mainly for libraries in universities and the larger museums. It will be of particular value to those interested in the ornithological history and early naturalists of the North Pacific.

C. STUART HOUSTON

863 University Drive, Saskatoon, Saskatchewan S7N 0J8

Spatial Orientation: The Spatial Control of Behavior in Animals and Man

By H. Schone. 1984. Princeton University Press, Princeton. 347 pp., illus. Cloth U.S. $55.00; paper U.S. $14.50.

Barn Owls catching mice in the dark, beach fleas leaping in the surf, humans tilting on ferris wheels, fish shifting their posture in rotating tanks: these are among the multitude of examples discussed in this thorough yet succinct account of orientation to spatial cues. Animal behaviour can be approached by using different overall frameworks (such as evolutionary adaptationism or Skinnerian psychology), and this book makes manifest that one such viable framework is the investigation of orientation mechanisms. The work is intended for a wide audience, provides over a 1000 references and index, and presents relevant data with good illustrations. In a brief introduction Schone clearly distinguishes biological questions of ultimate and proximate causation, of function and mechanism, and directs attention to the latter for an examination of the topic at hand. He is careful to avoid reductionism, however, and later emphasizes the emergent nature of successive levels of biological organization. Of the three chapters, the short first one outlines definitions and the nature and function of orientation movements. The focus of the second chapter is the physiology of orientation, including the features of the stimuli, the anatomy and physiology of the sensory and motor systems, and related topics such as space constancy. The huge third chapter, making up half of the text, examines each sensory modality, such as visual, chemical, and magnetic cues.

The volume is dedicated to the author's teacher, Erich von Holst, who contributed so much to the topic, and stands solidly in the proud European tradition of works by Loeb, Kuhn, and Fraenkel and Gunn. The inclusion of historical antecedents in the various subjects under discussion provides helpful perspectives. Cybernetics, the science of feedback established by Norbert Wiener, has had a strong and useful impact on the study of orientation mechanisms through applications. Initiated by Mittelstaedt and Hassenstein, this study has advanced the field in exhilarating directions. In the context of this approach many issues are reviewed, such as models for resetting the reference values against which animals evaluate sensory input. Needed terminology is introduced appropriately, without wearying the reader. There is good treatment of such matters as the interaction of multiple cues and the ontogeny of orientation, and data for humans and animals are reported. The emphasis is on the underlying mechanisms, and when knowledge of these is poor, as in the case of temperature selection, Schone is brief. Surprisingly, the con-

sideration of the mechanisms permitting distance perception is confused and redundant. A concluding section, in which an overview and prospects for further work were presented, would have served as a welcome denouement after an otherwise excellent review.

Many investigations of the mechanisms of animal behaviour are undertaken out of fascination with how very different organisms perceive the world and deal with it. Such investigations offer the most fruitful approach to the comprehension of the animal mind, and Schone's book testifies to this fruitfulness.

PATRICK COLGAN

Biology Department, Queen's University, Kingston, Ontario K7L 3N6

Michigan Mammals

By Rollin H. Baker. 1983. Wayne State University Press, Detroit, Michigan. xx + 642 pp., illus. U.S. $60.00.

The 37 years since the publication of W.H. Burt's *The Mammals of Michigan* have seen a substantial expansion of knowledge on the biology of mammals. Baker's current work successfully compiles this knowledge into a large, but very readable volume. Seventy-one species are treated, 66 of which are native to Michigan, three introduced, and two not actually recorded from the state, but expected because of proximity to state borders. Only two species (the Smoky Shrew, *Sorex fumeus* and the Eastern Pipistrelle, *Pipistrellus subflavus*) have been added to Burt's 1946 list.

The species accounts include sections on the origin and meaning of the scientific name, description (including skull), distribution (including county records), habitat, density and movements, behavior, associates, reproduction, food, enemies, parasites/diseases, molt and color aberrations, and economic importance. A wealth of information is included in the accounts. Three to five pages each is typical even for lesser known species (e.g. Pygmy Shrew, *Sorex hoyi*); 10–12 pages are devoted to well-known forms such as the Black Bear, *Urus americanus*, and the Deer Mouse, *Peromyscus maniculatus*. Literature is cited through 1982 and typically includes papers encompassing the entire range of a species which broadens the geographical usefulness of this work.

Two keys to the species in each order are included: one utilizes characteristics of "adult animals in the flesh" and one utilizes skull characteristics. The keys appear to be useful to both the professional and the non-specialist especially in conjunction with the excellent glossary. A separate key to orders is not included. An introductory section of 16 pages includes an interesting discussion of the distribution of Michigan mammals as influenced by the water barriers of the Great Lakes and associated rivers, broad habitat affinities, post-glacial history, and the effect of settlement. The work is greatly enhanced by numerous sketches, photographs, drawings, and six color plates. Unfortunately, the distribution maps detract from the otherwise high quality of this book; indistinct shading on some maps renders them essentially useless. On the whole, the book is remarkably free of errors.

Overall, Baker has produced an excellent work. It is packed with information, but is written in an informal style and reads well. Although Baker states that it is "not intended to be an all-inclusive account of Michigan mammals", the book really is just that — at least through 1982. The price of $60 may seem high until one considers that on a price/kg basis, this work is no more expensive than smaller state or regional treatments.

DAVID A. LOVEJOY

Biology Department, Westfield State College, Westfield, Massachusetts 01086

Fishes of the North-Eastern Atlantic and the Mediterranean / Poissons de l'Atlantique du Nord-Est et de la Méditerranée

Edited by P. J. P. Whitehead, M.-L. Bauchot, J.-C. Hureau, J. Nielsen, and E. Tortonese. 1984. UNESCO, Paris. Volume I. 510 pp., illus. 250 FF.

This is the first of three volumes of *Fishes of the north-eastern Atlantic and Mediterranean* (FNAM), the long awaited authoritative ichthyofauna of the marine fishes of Europe. It is the progeny of Clofnam: "Check-list of the fishes of the north-eastern Atlantic and of the Mediterranean." The geographic area covered by FNAM extends from eastern Greenland to Europe, north and east to Spitzbergen and western Novaya Zemlya, and south to 30° N including the Azores, Madeira, most of Morocco, all of the Mediterranean, and the Black and Caspian seas.

FNAM is divided into a Foreword (by Théodore Monod), Editor's Note, List of Contributers (73 scientists), List of Families (for all 3 volumes), Key to Families (in all 3 volumes), and 64 family accounts with contained species — Petromyzonidae to Anotopteridae. Volume II will contain families Mirapinnidae to Xiphiidae, and III Gobiidae to Linophrynidae plus references supplemental to Clofnam, and indices to common and scientific names.

The key to families usually uses one or two characters per couplet. Except at the class level, the key does not attempt to be phylogenetic and some families key out in more than one place which should facilitate identification of polymorphic families. A useful feature is the inclusion of headings in the body of the key, e.g. Hagfishes, lampreys; Bony fishes; Pelvic fins absent; Adipose fins and photophores present. This will permit the user with experience to skip the beginning of a series of couplets and arrive more quickly at an identification. Outline drawings are given for each family in the key, but there are only three text-figures to illustrate key characters.

A typical family account is composed as follows. The scientific name of the family is followed by the author of the account and vernacular names in English, French, Spanish and sometimes Russian and German. Two paragraphs follow, one giving a morphological description and the second a summary of the biology of the family. The number of world and Clofnam area genera is listed and recent revisions are cited. Keys to genera and species may be combined or separated; keys usefully give page numbers of species accounts. Figures may be included to explain characters such as location of photophores and shape of teeth.

Following a generic name heading is a short description of the genus, the number of world and Clofnam area species, common synonyms and vernacular names. Species accounts contain a Diagnosis (diagnostic characters, colour, usual and maximum size). Habitat (plus food and reproduction), and Distribution paragraphs. Some have in addition a Note which will explain differences in nomenclature from Clofnam or indicate unresolved taxonomic problems.

A black-and-white drawing about 2/3 of the page wide and a spot or shaded range map 1/3 of the page wide accompanies each species account. The drawings, supplied by the different authors, vary in style, but most are of acceptable quality. The maps are small (4 cm deep) and some give spot distributions but most use various types of hatching to describe distributions in general terms.

The taxonomic names are up-to-date although displaying a moderate conservatism. Some literature is missed. Under Recent revisions for *Coregonus*, Reshetnikov (1980) is listed but Svardson's (1979) major study is ignored. Common names are those adopted by FAO; these not infrequently differ from North American usage, *viz.* FNAM usage of starry skate and raie radiée for *Raja radiata*, instead of thorny skate and raie épineuse. It would be worthwhile to make an effort to standardize common names of widespread species.

The high standard of the contributions and editing observed in Clofnam has been maintained. The reader is supplied with a well-organized, authoritative, and highly readable text. When the volumes are complete the reader will be able to identify 1256 species in 218 families and will have, on average, a half-page summary of information on each species. There is a fair amount of blank space on many pages. Some of this could have been used to include more text, but perhaps that would have sacrificed esthetics. It would have been useful to have each author's contribution dated so that in a few years readers will know the period that has elapsed since literature on the taxon was summarized. Some families may have been completed several years earlier than others and are therefore less up to date. Modern systematics moves quickly!

The typography, page design and matte paper are esthetically pleasing. The plasticized blue cover is water resistant. The signatures appear to be glued together rather than sewn, which does not promise well for the durability of the binding.

This is a major contribution to European and world ichthyology. The contributors, editors and Unesco are to be congratulated, especially editors who had to ride herd over a multiplicity of personalities.

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Svardson, G. 1979. Speciation of Scandinavian *Coregonus*. Institute of Freshwater Research Drottningholm (57): 1–95.

DON E. MCALLISTER and BRIAN W. COAD

Ichthyology Section, National Museum of Natural Sciences, Ottawa, Ontario K1A 0M8

BOTANY

Past and Present Vegetation of the Far Northwest of Canada

By J. C. Ritchie. 1984. University of Toronto Press, Toronto. 251 pp., illus. $35.00.

This book treats only a small part of northwestern Canada. This part, however, is most interesting because a large portion was left unglaciated during the Wisconsin glaciation. The area extends roughly from 65°40′N, north to the Arctic Coast and from 127°40′W west to the Alaskan border and encompasses some 220 000 square kilometers. It is not an area of easy access.

The author has brought together the results of his own and his students' 15 years of field work in the area plus those of other workers. He has termed the book "a status report on 15 years of research into the historical plant ecology of northwest Canada".

The book is divided into seven chapters, most of which are again subdivided: (1) Introduction; (2) The physical setting (climate, geology, permafrost and periglacial features, and physiographic regions); (3) Vascular plant floristics; (4) Modern vegetation (Beringian vegetation zones and Present vegetation of Northwest Canada); (5) Vegetation history (Tertiary origins, Early and middle Pleistocene, and Late Pleistocene and Holocene record); (6) Palaeoenvironmental reconstruction (The full- and late-glacial vegetation, The early Holocene period, and The late Holocene alder rise and subsequent stability; and (7) Current problems and future trends (Ecological implications of the palaeobotanical record, Topographic diversity and palaeoecology, and For the future). Appendices include (1) a listing of the vascular plants that have been recorded for the study area; (2) tabular summaries of the vegetation composition of the main community types; (3) field and laboratory methods; and (4) a listing of the radiocarbon age determinations of samples taken. A collection of 28 plates that illustrate physiographic features and vegetation types, a list of references and an index complete the volume. The plates would have been better if they had been printed on glossy paper.

From his studies, Dr. Ritchie has been able to question the hypothesis of a grassland vegetation in north Yukon and to suggest on the basis of the pollen record "that at least in eastern Beringia the herb zone represents a sparse, discontinuous vegetation of herbaceous tundra on upland sites and local sedge-grass meadows on lowlands". This is a most important contribution to our knowledge of the region. He has also been able to suggest new lines of investigation that might be followed to further understand the vegetational history of the region.

WILLIAM J. CODY

Biosystematics Research Centre, Agriculture Canada, Ottawa, Ontario K1A 0C6

Our Green and Living World: The Wisdom to Save It

By E. S. Ayensu, V. H. Heywood, G. L. Lucas, and R. A. DeFilipps. 1984. Cambridge University Press. 256 pp., illus. U.S. $24.95.

I have been looking for a book like this for years. Here for popular reading is a reliable introduction to the world's major regions of vegetation and to man's uses and abuses of them. Here also are brief accounts crammed with interesting facts on the importance of plants to man's welfare. To characterize the book in a sentence, it is a readable, informative, and well illustrated account of man and plants, which is presented with a deep concern for the future of both that is based on world wide knowledge and understanding.

Standing in the background behind this book's message are two world-oriented organizations by far the best informed on Earth's natural history: the International Union for the Conservation of Nature (IUCN) and the World Wildlife Fund (WWF). Richly published by Cambridge University Press to mark its 400 years of continuous publishing, it was co-published in Washington by the Smithsonian Institution which is the largest museum and science organization in the world.

The book is most obviously a pictorial essay on the world's plants and its people, a lavish display of good printing in which 256 large pages present 251 illustrations in full colour along with a few dozen others not coloured. These are without exception excellent creations of photographer and printer, and are honoured as such by unusually informative captions throughout. The trend today in colourful books is captions that are clearly last minute fillers by writers with little to say. It is a delight to both eye and mind to linger for a change over pictures having words that add to meaning and enjoyment, all of which suggests that while a picture may be worth a thousand words, all of us need experts to translate most pictorial messages.

Throughout this colourful display, and often referring to the pictures in detail, is a text written by four authors who together have global experience with people and the plants they live with, and would often die without. It is a good book to read, not complete in coverage for no popular book should even try to cover all of so large a subject, but it is an introduction with much detail of interest to a general audience. It should be made available in many languages.

I had been looking for an informed account of the accelerating exploitation of tropical rain forests around the world, and found it in this book. My impression while reading this especially well-covered topic was that concern for this destruction of unknown resources containing most of this planet's forms of life was probably a primary incentive for deciding to create this book. I found here also first hand information on the harvesting and marketing of drug producing plants; the plant sources of many medicines; the uses of plant fibers by many cultures; the staple plant foods of man and where they originated; and the shortages of fuel for cooking found throughout the Third World. Major recent advances in plant cultivation and reforestation are noted, and there are some glimpses of superior food plants suitable for cultivation in the tropics which are being ignored by hungry nations.

This book is not only a memorable world tour of native vegetations, it is a revealing look at mankind with emphasis on the hungry nations and how their people survive. Here is the family of man, which most of us in affluent nations forget is dominated by problems quite unlike ours, problems that can in the final analysis be solved only by plants. Here the story is told well in words and pictures that together say very clearly: without plants there can be no man. Destroy the plants and man goes with them.

YORKE EDWARDS

663 Radcliffe Lane, Victoria, British Columbia V8S 5B8

Mate Choice in Plants: Tactics, Mechanisms, and Consequences

By Mary F. Willson and Nancy Burley. 1983. Monographs in Population Biology 19. Princeton University Press, Princeton. 251 pp., illus. Cloth U.S. $35; paper U.S. $12.50.

Broadly speaking, plants produce many pollen grains but few seeds. If it is not pure random chance that determines which pollen are successful and which die, then there is the possibility of selection in favour of those that are in some way better than the others. Willson and Burley here marshal evidence supporting the idea that plants have taken advantage of this option through evolutionary time.

The unwritten subtitle of the book must be Sociobiology of Plants, for its mode of thinking is very much in the tradition of E.O. Wilson and company, and it makes extensive use of the sociobiological literature on mate choice and sexual selection (which is, of course, founded almost entirely on animals). Parents invest in their offspring and make trade-offs between present and future reproduction. Offspring compete with their siblings, their parents, their own offspring, and their mates, and generally carry on as ultra-rational selfish planners, at least as a first theoretical approximation. I cannot agree with those who say this way of thinking is wrong in itself — it's actually rather elegant — but it does require intelligent interpretation by the reader. Add to this the fact that the argument ranges through the minutiae of plant reproductive mechanisms (one of the true horrors of introductory biology) and the result is that the book is not light reading.

The main argument is clearly stated and supported. Its main elements are that typically a) female reproductive success is limited by resources of some kind, not by availability of pollen, b) male reproductive success is limited by opportunities for fertilizations, and c) plants possess mechanisms by which these sexual differences in constraints are expressed, if not resolved. Some of the possibilities are quite simple. For example, two pollen tubes growing down towards an ovule which only the first can fertilize are engaged in a male-male contest. This allows the female to judge the vigour (eg. growth rate), stamina, and competitive ability of her two suitors. It may be less spectacular

than two rams butting on a mountain ridge, but it is really much the same biologically — pure sexual selection. The males may respond by evolving larger pollen grains that grow faster, but only at the expense of poorer dispersal. The females may suppress growth of pollen tubes until many grains have accumulated, so that the choice is made from a larger set of candidates, but only by forgoing the demographic advantages of early reproduction. Many other more complex possibilities exist as well, some of which may help to explain curious things such as triploid endosperm. The discussion is not all easy to understand, but it is stimulating and has the salutary effect of further eroding the obsolete distinction between botany and zoology.

Half the book consists of tables of data and references, and, no doubt as an anti-philistine precaution, it ends with no fewer than fifty-four testable hypotheses. Nevertheless, as with the other books in this series, it is clearly aimed at the theoretician, not the collector of facts. There is nothing here on how the world looks, but much of interest on how it might work.

JOHN MIDDLETON

Institute of Urban and Environmental Studies, Brock University, St. Catharines, Ontario L2S 3A1

Plant Variation and Evolution

By D. Briggs and S. M. Walters. 1984. Second Edition. Cambridge University Press, New York. xiv + 412 pp., illus. U.S. $17.95.

This book, prepared by botany professors at the University of Cambridge, will be useful to undergraduate and graduate students and researchers in the field of plant systematics and evolution. As well, naturalists and amateur botanists upon studying the book may make more valuable contributions to our knowledge of plant evolution by means of simple observation and experiment on populations of plants found in areas with which they are familiar.

The 1984 edition is a largely rewritten update of the 1969 edition. The authors' aim is "to show how one branch of biology — namely the study of variation and evolution — has developed in the last 300 years" and in particular the critical role of hypothesis and experiment in the advancement of knowledge in this field.

In this reviewer's opinion the greatest value of this book lies in the copious use of examples including literature citations, showing the dozens of different kinds of evolutionary specializations or "adaptations" that have evolved in nature and also the portrayal of the generalized conditions from which these more specialized structures originated. The focus is on the interpretation of the genetic and environmental basis for diversification and adaptation using examples from a very broad cross section of families, genera, and species. Field observations and experimental work interpreting or analyzing the nature and extent of "microevolutionary" changes — the kinds of changes that take place within local populations — will give the serious reader new insights into the dynamic nature of plant populations, especially those that are successfully adapting to man's activities. As well, the book brings together the kinds of information about variation and evolution that can make the untrained botanist question assumptions regarding the validity of many Latin names which are so often considered to be "carved in stone."

Among the principal modern topics covered in the book are the origins of breeding systems, infraspecific variation, the ecotype concept, gradual and abrupt speciation, hybridization, genecology, biosystematics, and evolutionary patterns in general.

The authors end the book with an observation that naturalists and professional scientists should concentrate more on studying living plants in their outdoor environment since we are now witnessing a drastic impoverishment of the world's flora.

THEODORE MOSQUIN

Mosquin Bio-Information Limited, Box 279, Lanark, Ontario K0G 1K0

Oaks of North America

By Howard Miller and Samuel Lamb. 1985. Naturegraph Publishers, Happy Camp, California. 327 pp. Cloth U.S. $14.95; paper U.S. $9.95.

Anyone interested in oaks will find useful and interesting information in this book. The authors, both of whom have done graduate work in forestry, begin by presenting a "past history" of the oak from the Cretaceous Period to the present. The value of oaks to the deciduous forest ecosystem is discussed, including their importance as wildlife food and cover. Common pests of oak are discussed and pictured (i.e. the chestnut borer and the *Armillaria* fungus).

The authors indicate that oak hybridization occurs with some frequency and can make identification difficult, but there is no discussion of what groups should be recognized as species and why. The book includes several keys, a winter twig key reprinted from Harlow's "Fruit and Twig Key to Trees and Shrubs", a "Growing Season Key for the Eastern Oaks", and a number of keys to western species (Texas, Mexico, Southwestern, Pacific). I found the growing season key confusing because of the number of choices (as many as 8) available at a particular point; however, the twig key worked very well for winter twigs.

The major part of the book, the part I think is most valuable, is a series of descriptions of North American oaks. For each species, and many varieties, the scientific and common names are listed, as well as descriptions of growth habit, bark, leaves, fruit and twigs, and buds. This is followed by a general discussion of the species as a part of a particular ecosystem, a range map, and good black-and-white photographs of bark, twig, acorns and leaves. I recommend this as a useful reference for anyone interested in North American forests in general and oaks in particular.

CAROL B. KNOX

Box 76, Cutler Science Center, Mount Hermon, Massachusetts 01354

ENVIRONMENT

Environmental Effects of Off-road Vehicles: Impacts and Management in Arid Regions

Edited by Robert H. Webb and Howard G. Wilshire. 1983. Springer-Verlag, New York. xxix + 534 pp., illus. U.S. $49.80.

Environmental problems resulting from the use of off-road vehicles have been researched at numerous locations throughout the world. The purpose of this book is "to provide authoritative information on the physical and biological impacts of vehicles on desert ecosystems" and associated general management guidelines.

The book comprises an introduction and 22 chapters, divided into five major categories of interest: 1) physical effects of off-road vehicles, 2) biological effects of off-road vehicles, 3) rehabilitation potential, 4) the histories of special problem areas, and 5) management concepts and practices. The first chapter in category 1 (Chapter 2) provides a general introduction to soil and soil formation in arid regions of the world. This is an interesting and well written chapter; however, it is important to note that throughout the book emphasis is placed on problems in the United States primarily because most of the research has been completed there. The remaining four chapters in this category address the impact of soil stabilizers, soil compaction, water erosion, and wind erosion.

Category 2 begins with an overview of desert plant ecology by E. W. Lathrop and P. G. Rowlands (Chapter 6). In the following chapter, Lathrop reviews the effects of vehicles on desert vegetation. One of the most striking aspects of this book is the degree to which the chapters are interrelated. In addition to the citations, the authors refer to each other. This attribute will assist many readers in their efforts to develop a true understanding of the problems associated with the use of off-road vehicles. The remaining two chapters in this category address the effects of vehicle noise on desert vertebrates and the biotic responses to vehicles in arid land dunes. Unfortunately, the book does not address the effects of off-road vehicles on wildlife in great detail. The lack of information relating to large mammals is particularly noticeable. Vegetation is treated in considerably more detail.

Category 3 contains seven chapters which outline the problems and techniques of rehabilitation, including regeneration of desert pavement, control of rills and gullies, recovery of perennial vegetation, natural recovery of soils and vegetation following human disturbance, and the rehabilitation of powerline corridors. Examples are provided in each chapter. In addition, B. L. Kay and W. L. Graves review all the known revegetation studies completed in the deserts of California (Chapter 16), and discuss revegetation and stabilization techniques for disturbed vegetation (Chapter 17).

The three chapters in category 4 are devoted to case history studies on vehicular destabilization of hill slopes in Ogden, Utah; impacts of off-road vehicles in the Coorong Dune and Lake Complex of South Australia; and the hazards of chrysotile asbestos to people driving in an off-road vehicle area in California. D. Gilbertson, in his review of the Coorong Dune and Lake Complex, states that the principal effects of off-road vehicles to the environment include soil surface compaction, accelerated soil erosion, accelerated rates of burial in sand, destruction of vegetation, prevention of natural regeneration, decreased diversity of habitats, noise, direct physical impact on plants and animals and associated illegal hunting, impairment of resting places on longer distance coastal migration routes, and accelerated spread of alien plants and animals.

W.J. Kockelmen is responsible for the three chapters in the last category, which deal with management concepts, management practices, and education and regulation.

The book contains numerous black-and-white photographs, maps, statistical tables and graphs, and an author and subject index. It is an erudite account of the environmental effects of off-road vehicles in arid regions, and is recommended to academics and managers directly concerned with soil and vegetation management. Although less applicable to biologists, this volume will provide excellent background reading for those concerned with wildlife management in arid regions.

PAUL A. GRAY

Department of Renewable Resources, Government of the Northwest Territories, Yellowknife, Northwest Territories X1A 2N6

Mining, Land Use, and the Environment, II: A Review of Mine Reclamation Activities in Canada

By I. B. Marshall. 1983. Environment Canada Land Use in Canada Series No. 23. Supply and Services Canada, Ottawa. 288 pp., illus. Free.

This work is the twenty-third in *The Land Use in Canada* series. Its purpose is to provide a general overview of land reclamation activities in the mining sector in Canada from the early 1960s to the present.

Reclamation is defined as "any process that promotes soil conservation and the productive use of degraded or disturbed land." The author outlines the legislative and administrative policies that have evolved from the 1960s to date. Because of these changes and the advent of the Environmental Impact Assessments requirement (EIA), reclamation activity has grown in depth and in substance over this period.

Although a great deal of work has been done to enforce reclamation processes for mining areas, two problem areas still exist: the large backlog of unreclaimed sites and the varied application of EIA amongst the provinces. It is disappointing to note that only five of 10 provinces have an EIA requirement rooted in acts or regulation although seven of ten require EIA before approving new mine openings. The remaining provinces and Federal government rely exclusively on cabinet policy backed by order-in-council decisions issued under the authority of environmental legislation to ensure environmental safeguards. Therefore, there is the problem of standardization of legislation and its application in this field.

It must be remembered that environmental degradation does not recognize provincial and national boundaries. A standardized approach to environmental legislation is required to ensure a habitable environment for present and future generations.

This work provides the reader with a good overview of the activities and current legislation in mining land reclamation and is highly recommended.

G. D. MADIGAN

1934 Belmore Lane, Gloucester, Ontario K1B 4Z8

An Overview of the Environmental Impacts of Forestry, with Particular Reference to the Atlantic Provinces

By Bill Freedman. 1982. Institute of Resource and Environmental Studies, Dalhousie University, Halifax, Nova Scotia. 219 pp. $10.

The purpose of the work by Freedman is to assess the state of the knowledge and the environmental impact of forestry in Atlantic Canada. Its objectives are to provide an overall assessment of current research, suggestions for moderating identified negative impacts, and proposals for forestry research priorities.

Forestry is an important economic sector in the Atlantic provinces. A significant part of the population is employed in the harvesting, processing, or manufacturing of a variety of forest products. The husbanding of the resource for present and future generations to ensure long-term employment opportunities is a major concern. Improper management practices which affect site, wildlife, hydrology, etc. not only lead to a decline in this sector, but also have large external impacts on recreation, tourism, fishing, and other related economic components in Atlantic Canada.

Freedman states that there is little research being conducted specific to the Atlantic provinces. Although his literature review appears extensive, Freedman's thrust is that the literature for each field is sparse when related to the Atlantic region.

Freedman used a multidisciplinary approach to the forestry management problem in his literature review. However, no one can be expert in all areas. Because of the number of disciplines involved, a clear aim must be established and adhered to. The work does not provide this aim nor is this its purpose. This difficult task is left to various resource managers and perhaps the time has come to coordinate research efforts in this area through a central agency.

This work offers an interesting insight to the resource requirements of Atlantic Canada.

G. D. MADIGAN

1934 Belmore Lane, Gloucester, Ontario K1B 4Z8

The Planning and Management of Environmentally Sensitive Areas

By Paul F. J. Eagles. 1984. Longman, London. (Canadian distributer Academic Press, Toronto). 160 pp., illus. $24.50.

As Paul Eagles points out in the beginning of this book, the dramatic growth in human populations and associated land development and pollution are affecting world ecosystems in alarming ways. Changes in nutrient cycles, reduction of species diversity, and extinction are a few of the changes discussed. Resource management agencies and methods are available to stem this tide of change, and Eagles feels that local governments should be in the forefront of land use decisions. The book explores the potential role of local governments in solving environmental problems and preserving "environmentally sensitive" areas, and it contains enough specific information to serve as a "how-to" guide for someone in local government.

The section on "planning theory" shows how our latest knowledge can be incorporated into government decisions. There is discussion of the need to understand island biogeography, innate and learned behavior of populations, community organization, economics, and societal attitudes. Another section on designing planning strategy suggests guidelines for the implementation of regional surveys and includes a summary of the data needed for such surveys. Also presented are the criteria used in Canada and Great Britain in such surveys. A third section discusses how to set guidelines for the use of an area. A case study of a site in Ontario is presented as an example of how the guidelines and criteria were applied to a particular area. The book concludes with selected case studies of planning and management at the local government level in Great Britain, Japan, Canada, and the U.S.A., showing how young and old countries differ in their problems. For example, Eagles says that "private landowners in Japan and Britain are more willing to accept the limitation for a common good than are those in Canada".

This book is filled with suggestions and ideas for local approaches to environmental problems. I recommend it to anyone concerned with conservation planning; it is thoughtfully written, soundly based on current ecological research and liberally referenced.

CAROL B. KNOX

Northfield Mount Hermon School, Box 76, Cutler Science Center, Mount Hermon, Massachusetts 01354

Married to the Wind: a Study of the Prairie Grasslands

By Wayne Lynch. 1984. Whitecap Books, North Vancouver. 166 pp., illus. $39.95.

The Canadian Prairies have always been a favorite region for me. These vast, arid, open spaces are often referred to as a monotonous expanse. Far from true. When one takes the time to look closely, there is a variety of habitats and diversity of life forms that take advantage of them in this relatively harsh environment. This provides a special intrigue for the naturalist. Lynch is to be commended for the way he illustrates the intriguing interrelationships of life on the prairie grasslands, both in photographs and words.

On first opening this book, one is struck by the excellent and aesthetically reproduced photography. This alone would convince the most casual reader that the prairie grasslands really is a region worthy of our interest and enjoyment. For those most interested in "coffee table" books, the illustrations alone make this book worth the price. However, Lynch goes far beyond the photogenicity of the region. His discussions of the diversity of grassland life, general prairie ecology, historical and pre-historical developments, as well as his details of special habitats illustrated by anecdotes about some of the species which live here, are well written in a manner which holds the reader's interest. The authoritative descriptions could easily apply to readings for a first year university ecology class. At the same time they are written in a manner that the non-scientific reader who has never visited the region will understand and enjoy. For those who have special interests in the Canadian Prairies, or who plan to visit them, this book is essential reading.

The organization of the book follows a pattern which is both rational and useful. Discussions in each chapter are followed by relevant photographic illustrations. These photos and their captions complement the text rather than just repeating or illustrating facts. They often represent specific examples which illustrate the general theme of the chapter. The data presented in them are chosen to both illustrate and intrigue.

The initial chapters define the prairie grassland and discuss its geology, archaeology, and historical as well as present importance. We then learn interesting details about some of the special and often unique habitats such as Sandhills, Badlands, Coolees, and Wetlands. Did you know that 50% of North American ducks (up to 80% of some species) begin life in prairie wetland habitats? Each habitat is presented in terms of its ecological and human importance with examples of some of its more interesting plants and animals.

I found this book most interesting, easy to read, and informative. For these reasons I recommend it to anyone with an interest in the prairies or the diversity of our Canadian environment in general, whether this is from a scientific, field-naturalist, or just casual interest perspective.

WILSON EEDY

R.R. 1, Moffat, Ontario L0P 1J0

Encyclopedia of American Forest and Conservation History

Edited by Richard C. Davis. 1983. Macmillan, New York. Two volumes, 780 pp., illus. U.S. $150 (Cdn. $195).

The more than 400 articles in the 742 pages of text were written by some 200 contributors and the staff of the Forest History Society under Richard C. Davis' supervision. Davis had the assistance as well of an eleven-member editorial advisory board and over 125 outside reviewers. The articles stress the "history of forestry, conservation, forest industries and other related subjects in the United States." Five appendices show the status of all forest reserve and national forest sites created since 1891; similar information for all national parks; a chronological list of all federal statutes cited in the text; listings of the principal federal conservation and forestry officials who have served since 1891, and eighteen maps illustrating various elements in the development of public land jurisdiction around the nation.

Forest history clearly dominates the coverage in these volumes, but there are a number of articles dealing with other conservation matters. A substantial number of biographical articles are included, though a good many names which one might have expected to find among a list of America's leading conservation figures are missing. The articles which do appear are generally well-written, with helpful bibliographical guides to the most important source material. The quality of the paper, printing, and binding are excellent, such that these volumes should enjoy many years of use.

KEIR B. STERLING

U.S. Army Ordnance Center and School, Aberdeen Proving Ground, Maryland 21005

Environmental Assessment in Canada: Directory of University Teaching and Research 1982–1983

Edited by Bruce Rigby. 1984. Federal Environmental Assessment Review Office, Environment Canada, Ottawa. vii + 96 pp. Free.

This is the first in an annual series of bulletins designed to point out which Canadian universities and colleges are active in Environmental Impact Assessment (EIA) and Social Impact Assessment (SIA). It highlights the departments in those institutions that are engaged in teaching courses related to impact assessment, and lists researchers involved in EIA/SIA. It contains a bibliography of reports, discussion papers, articles, and books produced by the academic community, and a list of student papers.

Material was solicited from 35 degree-granting institutions. Coverage seems to be fairly uneven because some respondents have included teaching and research activities only vaguely related to impact assessment, while others have confined their listing to closely related subjects. The number of reported course offerings per institution in 1982–83 varied from 1 to about 20, and is roughly correlated with size of the university. In all institutions combined, impact assessment subject matter was taught by 15 or 20 different departments, ranging from Psychology to Soil Science, but Geography Departments led the way, followed by Schools of Planning and Departments of Environmental Studies or Environmental Design. These multi-disciplinary departments accounted for 70% of all listed course offerings in EIA/SIA. Research involvement by staff and graduate students showed a similar distribution.

It is encouraging to note that several Canadian universities offer courses in social impact assessment and in environmental law. Most Faculties of Engineering also have impact assessment courses, and some even offer basic ecology courses for engineers.

This publication should be useful to students searching for an institution that meets their interests, and to developers or regulators looking for specialized research expertise.

DONALD BLOOD

Site 60, Box 8, R.R. 1 Lantzville, British Columbia V0R 2H0

Ocean Yearbook 4

Edited by Elisabeth Mann Borgese and Norton Ginsberg. 1984. University of Chicago Press, Chicago. 607 pp. U.S. $49.

Ocean Yearbook 4 follows after three previous issues. It combines input from seventeen authors and two committees into one volume. Each author has contributed a section on a speciality. These subjects include living and non-living resources, shipping, science, environment, and military activities. Considering the broad spectrum of topics and the diverse nationalities of the authors, the yearbook is very uniform in quality and format. Credit for this must be given to the editors and they are to be congratulated for their efforts.

This book is not for the average reader. It is for reference and a way of keeping up to date with a host of maritime issues for researchers, policy makers, environmentalists, and lawyers.

I was more interested in the science subjects and I noted, with pleasure, that the principal objectives of ocean research are to develop a more fundamental understanding of the processes which occur in the world's oceans. In the past, too much effort has been expended on data gathering for its own sake, rather than on trying to bring our existing knowledge to a focus that would lead to scientific understanding.

The section on the environment is very interesting, particularly the chapter on Southeast Asia. Although many of the basic problems are similar to those we face in North America, there are many overriding deficiencies due to climate, culture, and regional demands. For example, we do not have to deal with tin poachers destroying benthic communities!

Do not expect, because of the subjects covered, that this book is written in a dry and crusty style. There is, of course, some difference between authors, and data and statistics can only be plainly stated. But the text is generally straightforward and easy to read and gets to be poetical on occasions. Let me give you one example; "One has to live and work aboard ship... and breath the wind of the sea and the smell of its organisms really to understand the fascination of marine research."

Anyone who has the previous issues will want to augment their set. All those with a serious interest in the sea should buy this book and think about getting, or at least reading, the previous volumes. I would not recommend it to the average reader, although one may want to borrow it for some specific reason.

ROY D. JOHN

8 Aurora Crescent, Nepean, Ontario K2G 0Z7

MISCELLANEOUS

Photography of Natural Things

By Freeman Patterson. 1982. Van Nostrand Reinhold. (Canadian distributor Key Porter Books, Toronto). 168 pp., illus. $12.95.

The author has gained the reputation of a leading Canadian photographer and writer. His previous works, *Photography For The Joy Of It* and *Photography And The Art Of Seeing* (reviewed in *The Canadian Field-Naturalist* 95(2):125) have been very well received by photographers in Canada and abroad.

Expressions of Patterson's skill to make images of natural things have occurred throughout the first two books. However, it is not until the present treatise that the author gives full attention to this fascinating topic. For the reader the wait has been worthwhile — nature photography has seldomly been described in such an interesting and competent manner.

Perhaps the primary reason that this book works so well is its unique and pleasing organization. Patterson's approach to presenting the elements of nature is so logical that understanding the flow of the text is never a problem. The author provides simplicity for the most complex of entities — nature itself.

The topics in the text are presented as elements of nature in ascending order: the physical elements first — sun and atmosphere, water, soil and landscape — and the biological elements next — the plants and animals.

Each element of nature is discussed with thrifty verbiage that is intended to pique the photographic curiousity of the reader. The sections on birds and mammals will be of particular interest to the field naturalist. The author demonstrates, quite convincingly, that images of animal species can represent the relationship of organism to environment, not simply provide an animal portrait.

All too often works on the photography of nature become technical "how to" manuals. The fact that Patterson has diverged from this format makes the book a pleasure to read. But in the end it is Patterson's own insight into nature and ability to describe the relationship of photography to natural things that makes this book a "must read" for every outdoors photographer.

It cannot be guaranteed that the reader's photographic skills will improve following reading this work; only practice will effect improvement. But one's appreciation and understanding of natural things will undoubtedly be greatly enhanced.

AL KENNEDY

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NEW TITLES

Zoology

*__American insects: a handbook of the insects of America north of Mexico.__ 1985. By Ross H. Arnett, Jr. VanNostrand Reinhold (Canadian distributor: Canada Publishing Corporation, Toronto). xiii + 850 pp., illus. $108.95.

†**An annotated bibliography of literature on the spotted owl.** 1984. By R. W. Campbell, E. D. Forsman, and B. M. Van Der Raay. British Columbia Ministry of Forests Land Management Report No. 24. Queen's Printer, Victoria. 115 pp. $7.50.

Atlantic fisheries and coastal communities: fisheries decision-making case studies. 1984. Edited by Cynthia Lamson and Arthur J. Hanson. Institute for Resource and Environmental Studies, Halifax. x + 252 pp., illus. $18.50.

The atlas of breeding birds of Vermont. 1985. Edited by Sarah B. Laughlin and Douglas P. Kibbe. University Press of New England, Hanover, New Hampshire. 478 pp., illus. U.S. $45.

†**The bald eagle in Canada.** 1985. Edited by Jon M. Gerrard and Terrence N. Ingram. Proceedings of Bald Eagle Days, 1983. White Horse Plains, Headingley, Manitoba. viii + 273 pp., illus. $20.

*__Bear attacks: their causes and avoidance.__ 1985. By Stephen Herrero. Nick Lyons Books (Canadian distributor: Hurtig, Edmonton). 288 pp., illus. Cloth $19.95; paper $12.95.

†**Biology and management of mountain ungulates.** 1985. By Sandro Lovari. Croom Helm, Beckenham, England. 271 pp., illus. £ 25.

†**Biology of Acanthocephala.** 1985. Edited by D. W. T. Crompton and B. B. Nickol. Cambridge University Press, New York. 512 pp., illus. $89.50.

*__Birds of China.__ 1984. By Rodolphe Meyer de Schauensee. Smithsonian Institute Press, Washington. 600 pp., illus. U.S. $42.

†**Birds of Nahanni National Park, Northwest Territories.** 1985. By George W. Scotter, Ludwig N. Carbyn, Wayne P. Neily, and J. David Henry. Special Publication No. 15. Saskatchewan Natural History Society, Regina. 74 pp., illus. $7.

†**Birds of New Guinea.** 1985. By Bruce M. Beehler, Thane K. Pratt, and Dale A. Zimmerman. Princeton University Press, Princeton. c370 pp., illus. Cloth U.S. $65; paper U.S. $37.50.

The birds of the Republic of Panama, part 4: Passeriformes: Hirundinidae (swallows) to Fringillidae (finches). 1984. By Alexander Wetmore, Roder F. Pasquier, and Storrs L. Olson. Smithsonian Institute Press, Washington. vi + 670 pp., illus. U.S. $29.95.

Butterflies of South America. 1984. By Bernard D'Abrera. Hill House, Ferny Creek, Victoria, Australia. 246 pp., illus. U.S. $19.50.

The centipedes and millipedes of Southern Africa: a guide. 1984. By R. F. Lawrence. Balkema, Rotterdam. xii + 148 pp., illus. U.S. $25.

Contaminant effects on fisheries. 1984. Edited by Victor W. Cairns, Peter V. Hodson, and Jerome O. Nriagu. Wiley–Interscience, New York. xviii + 333 pp., illus. U.S. $69.95.

Dictionary of animals. 1984. Edited by Michael Chinery. Arco, New York. 379 pp., illus. U.S. $17.95.

†**A dictionary of birds.** 1985. Edited by Bruce Campbell and Elizabeth Lack. Buteo Books, Vermillion, South Dakota. xxx + 670 pp., illus. U.S. $75.

The growth and development of birds. 1984. by Raymond J. O'Connor. Wiley-Interscience, New York. x + 315 pp., illus. U.S. $39.95.

†**A guide to the birds of Columbia.** 1985. By Steven L. Hilty and William L. Brown. Princeton University Press, Princeton. c750 pp., illus. Cloth U.S. $95; paper U.S. $42.50.

†**Honeybee ecology: a study of adaptation in social life.** 1985. By Thomas D. Seeley. Princeton University Press, Princeton. c204 pp., illus. Cloth U.S. $39.50; paper U.S. $14.50.

†**Hoverflies.** 1985. By Francis S. Gilbert. Cambridge University Press, New York. 96 pp., illus. cU.S. $16.95.

Hummingbirds: their life and behavior: a photographic study of the North American species. 1985. By Esther Quesada Tyrrell. Crown, New York. xii + 212 pp., illus. U.S. $35.

Insect conservation: an Australian perspective. 1984. by T. R. New. Junk (U.S. distributor: Kluwer, Boston). xiv + 184 pp., illus. U.S. $40.50.

Photoreception and vision in invertebrates. 1984. Edited by M. A. Ali. Plenum, New York. x + 858 pp., illus. U.S. $115.

*__Possums and gliders.__ 1984. Edited by Andrew Smith and Ian Hume. Surry Beatty and Sons, Chipping Norton, Australia. xv + 508 pp., illus. U.S. $52.

Second nature: the animal-rights controversy. 1985. By Alan Herscovici. Based on a three-part radio series. CBC Enterprises, Toronto. 256 pp., illus. $12.95.

Sharks: an introduction for the amateur naturalist. 1984. By Sanford A. Moss. Prentice-Hall, Englewood Cliffs, New Jersey. x + 246 pp., illus. Cloth U.S.$19.95; paper U.S. $10.95.

*__Waterfowl studies in Ontario, 1973–81.__ 1984. Edited by S. G. Curtis, D. G. Dennis, and H. Boyd. Canadian Wildlife Service Occasional Paper No. 54. Environment Canada, Ottawa. 69 pp., illus.

The wilderness guardian: a practical guide to fieldwork related to wildlife conservation. 1984. By Timothy Corfield. David Sheldrick Memorial Appeal, Box 48177, Nairobi, Kenya. 621 pp. U.S. $20 plus postage.

Wildlife adventures with a camera. 1984. By Erwin and Peggy Bauer. Abrams, New York. 208 pp., illus. U.S. $45.

†**Wings in the sea: the humpback whale.** 1985. By Lois King Winn and Howard E. Winn. University Press of New England, Hanover, New Hampshire. x + 151 pp., illus. Cloth U.S. $25; paper U.S. $15.95.

Botany

Alaska's forest resources. 1985. Edited by Walt Matell. Alaska Geographic Society, Anchorage. 200 pp., illus. U.S. $17.95 + U.S. $1 postage.

American arctic lichens, volume 1: the macrolichens. 1984. By John W. Thomson. Columbia University Press, New York. xvi + 504 pp., illus. U.S. $55.

The biology of the Actinomycetes. 1984. Edited by M. Goodfellow, M. Mordarski, and S. T. Williams. Academic Press, Orlando, Florida. x + 544 pp., illus. U.S. $95.

†**Botanical studies in the Lake Hazen Region, Northern Ellesmere Island, Northwest Territories, Canada.** 1985. By James H. Soper and John M. Powell. Publications in Natural Sciences 5. National Museum of Natural Sciences, Ottawa. vi + 67 pp., illus. Free.

Eastern forests. 1985. By Ann Sutton and Myron Sutton. Knopf, New York. 640 pp., illus. U.S. $14.95.

†**The evolutionary ecology of ant-plant mutualisms.** 1985. By Andrew J. Beattie. Cambridge University Press, New York. c176 pp., illus. Cloth cU.S. $32.50; paper cU.S. $13.95.

†**Grasslands studies.** 1985. By Juliet Brodie. Allen & Unwin, Winchester, Massachusetts. x + 100 pp., illus. U.S. $9.95.

***Guide to the literature for the identification of North American lichens.** 1985. By Irwin M. Brodo. Syllogeus 56. National Museum of Natural Sciences, Ottawa. 39 pp. Free.

Light and the flowering process. 1984. Edited by Daphne Vince-Prue, Bryan Thomas, and K.E. Cockshull. From a symposium, Littlehamptom, England, September 1983. Academic Press, Orlando, Florida. xxii + 301 pp., illus. U.S. $27.50.

Mushrooms and other fungi. 1984. By Aurel Dermek. Translated from the Czechoslovakian edition, 1981. Arco, New York. 223 pp., illus. U.S. $8.95.

†**The names of plants.** 1985. by D. Gledhill. Cambridge University Press, New York. xviii + 159 pp. Cloth U.S. $34.50; paper U.S. $9.95.

***Pondweeds and bur-reeds, and their relatives, of British Columbia.** 1985. By T. Christopher Brayshaw. Occasional Paper Series No. 26. British Columbia Provincial Museum, Victoria. 166 pp., illus. $15.

The primary source: tropical forests and our future. 1984. By Norman Myers. Norton, New York. xiv + 399 pp., illus. U.S. $17.95.

Environment

The Alaskan Beaufort Sea: ecosystems and environments. 1984. Edited by Peter W. Barnes, Donald M. Schell, and Erk Reimnitz. Academic Press, Orlando, Florida. xvi + 466 pp., illus. U.S. $39.

The Amazon: limnology and landscape ecology of a mighty tropical river and its basin. 1984. Edited by Harald Sioli. Junk (U.S. distributor: Kluwer, Boston). xiv 763 pp., illus. U.S. $172.

Antarctic ecology. 1984. Edited by R. M. Laws. Academic Press, Orlando. Volume 1: xviii + 344 pp., illus + index. U.S. $55. Volume 2: xviii + 505 pp., illus + index. U.S. $75.

Applied environmental geochemistry. 1983. Edited by Iain Thornton. Academic Press, Orlando, Florida. xiv + 501 pp., illus. U.S. $70.

Beauty and the beast: the coevolution of plants and animals. 1985. By Susan Grant. Scribner, New York. viii + 215 pp., illus. U.S. $14.95.

Biogeographical relationships between temperate eastern Asia and temperate eastern North America. 1984. From a symposium, St. Louis, September 1982. Missouri Botanical Garden, St. Louis. 329 pp., illus. U.S. $15.

Biogeography and ecology of the Seychelles Islands. 1984. Edited by D. R. Stoddart. Junk (U.S. distributor: Kluwer, Boston). xii + 691 pp., illus. U.S. $115.

Biography of the tropical Pacific. 1984. Edited by Frank J. Radovsky, Peter H. Raven, and S.H. Sohmer. Bernice P. Bishop Museum, Honolulu. x + 221 pp., illus. U.S. $45.

Biophilia. 1984. By Edward O. Wilson. Harvard University Press, Cambridge. 159 pp. U.S. $15.

California riparian systems: ecology conservation, and productive management. 1985. Edited by Richard E. Warner and Kathleen M. Hendrix. From a conference, Davis, California September 1981. University of California Press, Berkeley. xxx + 1035 pp., illus. Cloth U.S. $75; paper U.S. $30.

Classification and interpretation of some ecosystems of the Rocky Mountain Trench, Prince George Forest Region, British Columbia: first approximation. 1984. By D. V. Meidinger, G. D. Hope, and A. J. McLeod. British Columbia Ministry of Forests Land Management Report No. 22. Queen's Printer, Victoria. 308 pp. + 2 maps.

***Climatic change in Canada, 5: critical periods in the Quaternary climatic history of northern North America.** 1985. Edited by C. R. Harington. Syllogeus 55. National Museum of Natural Sciences, Ottawa. 481 pp., illus. Free.

The coevolution of climate and life. 1984. By Stephen H. Schneider and Randi Londer. Sierra Club Books (distributed by Random, New York). xii + 563 pp., illus. U.S. $25.

Current issues in toxicology: interpretation and extrapolation of chemical and biological carcinogenicity data to establish human safety standards; the use of short-term tests for mutagenicity and carcinogenicity in chemical hazard evaluation. 1984. Edited by H. C. Grice. Springer-Verlag, New York. x + 197 pp. U.S. $18.50.

Decision making: the role of environmental information. 1984. Proceedings of a conference, 18 March 1984. Canadian Society of Environmental Biologists, Edmonton. 126 pp. $10.

Ecological aspects of radionuclide release. 1983. Edited by P. J. Coughtrey, J. N. B. Bell, and T. M. Roberts. Blackwell Scientific, Palo Alto. xiv + 279 pp., illus. U.S. $60.

Ecological communities: conceptual issues and the evidence. 1984. Edited by Donald G. Strong, jr., Daniel Simerloff, Lawrence G. Abele, and Anne B. Thistle. From a symposium, Wakulla Springs, Florida, March 1981. Princeton University Press, Princeton. xiv + 614 pp., illus. Cloth U.S. $60; paper U.S. $22.50.

Ecology and biogeography in Sri Lanka. 1984. Edited by C. H. Fernando. Junk (U.S. distributor: Kluwer, Boston). xx + 505 pp., illus. U.S. $110.

†**The ecology of biological invasions.** 1985. Edited by R. H. Groves and J. J. Burdon. c255 pp., illus. cU.S. $44.50.

Energy, economics, and the environment. 1985. By Russell Mills and Arun N. Toke. Prentice-Hall, Englewood Cliffs, New Jersey. xvi + 496 pp., illus. U.S. $34.95.

Environmental dispute resolution. 1984. By Lawrence S. Bacow and Michael Wheeler. Plenum, New York. xvi + 372 pp., illus. U.S. $29.50.

The environmental effects of nuclear war. 1984. Edited by Julius London and Gilbert F. White. A.A.A.S. Symposium Series 98. From a symposium, Detroit, May, 1983. Westview, Boulder, Colorado. xii + 204 pp., illus. U.S. $24.

Environmental exposure from chemicals, volume 1: introduction, and volume 2: environmental systems analysis. 1985. Edited by W. Brock Neely and Gary E. Blau. CRC Press, Boca Raton, Florida. 256 pp. U.S. $92 (outside U.S.A.) and c192 pp U.S. $69 (outside U.S.A.)

Environmental politics and policy. 1984. By Walter A. Rosenbaum. Congressional Quarterly, Washington. x + 328 pp. U.S. $10.50.

Estuarine management and quality assessment. 1985. Edited by J. G. Wilson and W. Halcrow. Proceedings of a symposium Dublin, Ireland, 20–22 September, 1982. Plenum, New York. c225 pp. U.S. $45.

†**Experimental behavioral ecology and sociology.** 1985. Edited by B. Holldobler and M. Lindauer. Sinauer, Sunderland, Massachusetts. xv + 488 pp., illus. Cloth U.S. $55; paper U.S. $30.

Freshwater biological monitoring. 1984. Edited by D. Pascoe and R. W. Edwards. Pergamon, New York. viii + 167 pp., illus. U.S. $35.

A guide to the Coastal Western Hemlock Zone, Northern Drier Maritime Subzone (CWHF), in the Prince Rupert Forest Region, British Columbia. 1984. By S. Haeussler, J. Pojar, B. M. Geisler, D. Yole, and R. M. Annas. British Columbia Ministry of Forest Land Management Report No. 21. Queen's Printer, Victoria. 172 pp. + 2 maps.

The handbook of environmental chemistry, volume 2, part c: reactions and processes. 1985. Edited by O. Hutzinger. Springer-Verlag, New York. xiv + 145 pp., illus. U.S. $36.

Hazardous waste management: in whose backyard? 1984. Edited by Michalann Harthill. From a symposium, Toronto, 1981. American Association for the Advancement of Science (publisher Westview, Boulder, Colorado). xii + 205 pp., illus. U.S. $22.

***Historical account of Byron Bog (Sifton Botanical Bog) London, Ontario.** 1985. By W. W. Judd. Phelps, London. iii + 61 pp., illus. $5.

***How to find information on Canadian natural resources.** 1985. By Gabriel Pal. Canadian Library Association, Ottawa. v + 182 pp. $25.

The interpretation of ecological data: a primer on classification and ordination. 1984. By E. C. Pielou. Wiley-Interscience, New York. xiv + 263 pp., illus. U.S. $32.50.

Lake sediments and environmental history: studies in paleolimnology and paleoecology in honour of Winifred Tutin. 1984. Edited by Elizabeth Y. Haworth and John W. G. Lund. University of Minnesota Press, Minneapolis. xviii + 411 pp., illus. U.S. $55.

Marine coastal protected areas: a guide for planners and managers. 1985. By Rodney Salm. IUCN, Gland, Switzerland. 302 pp., illus. U.S. $20 plus U.S. $2 postage.

Measuring the benefits of clean air and water. 1984. By Allen V. Kneese. Resources for the Future, Washington. xiv + 159 pp., illus. U.S. $5.95.

Mediterranean marine ecosystems. 1985. Edited by Maria Moraitou-Apostolopoulou and Vassili Kiortsis. Proceedings of a conference, Heraklion, Crete, 23–27 September, 1983. Plenum, New York. c410 pp. U.S. $65.

†**A natural history of Digges Sound.** 1985. By A. J. Gaston, D. K. Cairns, R. D. Elliot, and D. G. Noble. Canadian Wildlife Service Report Series No. 46. Supply and Services Canada, Ottawa. 63 pp., illus. $8 in Canada; $9.60 elsewhere.

†**Natural selection in the wild.** 1986. By John A. Endler. Princeton University Press, Princeton. c240 pp., illus. Cloth U.S. $40; paper U.S. $13.95.

New directions in environmental impact assessment in Canada. 1985. Edited by Virginia W. Maclaren and Joseph B. Whitney. Proceedings of a workshop, October 1983. Methuen, Toronto. 245 pp., illus.

A new ecology: novel approaches to interactive systems. 1984. Edited by Peter W. Price, C. N. Slobodchikoff, and William S. Gaud. From a conference, Flagstaff, Arizona, August 1982. Wiley-Interscience, New York. xii + 515 pp., illus. U.S. $59.95.

Organic chemicals in natural waters: applied monitoring and impact assessment. 1984. By James W. Moore and S. Ramamoorthy. Springer-Verlag, New York. xii + 289 pp., illus. U.S. $39.80.

Principles of water quality. 1984. By Thomas D. Waite. Academic Press, Orlando. xii + 289 pp., illus. U.S. $45.

***The status of ecological reserves in Canada.** 1985. By P. M. Taschereau. The Canadian Council on Ecological Areas and the Institute for Resource and Environmental Studies, Dalhousie University, Halifax. vii + 120 pp., illus.

Tropical rain forests of the far east. 1984. By T. C. Whitmore. Second edition. Clarendon (Oxford University Press), New York. xvi + 352 pp., illus. U.S. $64.

Miscellaneous

†**The bicentennial of John James Audubon.** 1985. By Alton A. Lindsey. Indiana University Press, Bloomington. xiii + 175 pp. U.S. $17.50.

Biotechnologies: challenges and promises. 1984. By Albert Sasson. UNESCO, Paris. 315 pp., illus. 85 FF.

Controversial chemicals — a citizen's guide. 1984. By P. Kruus and I. M. Valeriote. Multiscience Publications, Montreal. 240 pp. $14.50.

*__Evolution: the history of an idea.__ 1984. By Peter J. Bowler. University of California Press, Berkeley. xiv + 412 pp., illus. U.S. $29.95.

†**Information in biological systems: the role of macromolecules.** 1984. By Werner Holzmuller. Cambridge University Press, New York. ix + 147 pp., illus. Cloth U.S. $32.50; paper U.S. $9.95.

*__The life and letters of Alexander Wilson.__ 1983. By Clark Hunter. Memoirs, Volume 154. American Philosophical Society, Philadelphia. xii + 460 pp., illus. U.S. $50.

Microcomputers in biology: a practical approach. 1984. Edited by C. R. Ireland and S. P. Long. IRL Press, Washington. xii + 324 pp., illus U.S. $27.

†**Museum collections: their roles and future in biological research.** 1985. Edited by E. H. Miller. Occasional Paper No. 25. British Columbia Provincial Museum, Victoria. x + 219 pp., illus. U.S. $20.

Natural acts: a sidelong view of science and nature. 1985. By David Quammen. Schocken, New York. xvi + 221 pp. U.S. $16.95.

*__The visual display of quantitative information.__ 1983. By E. R. Tuft. Graphics Press, Cheshire, Connecticut. 197 pp., illus. U.S. $34 postpaid.

Books for Young Naturalists

Alligator. 1984. By Jack Denton Scott. Putnam's, New York. 64 pp., illus. U.S. $11.95.

The alligator. 1984. By Susan Dudley Morrison. Crestwood, Mankato, Minnesota. 47 pp., illus. U.S. $8.95.

Animals in the wild: elephant; monkey; tiger. 1984. By Mary Hoffman. Random House, New York. 22 pp., illus. each. U.S. $1.50 each.

Building your own nature museum for study and pleasure. 1984. By Vinson Brown. Second edition. Arco, New York. xii + 161 pp., illus. Cloth U.S. $12.95; paper U.S. $7.95.

The Caribou. 1984. By Jerolyn Ann Nentl. Crestwood, Mankato, Minnesota. 47 pp., illus. U.S. $8.95.

Dictionary of animals. 1984. Edited by Michael Chinery. Arco, New York. 379 pp., illus. U.S. $17.95.

Gorilla. 1984. By Robert M. McClung. Morrow, New York. 92 pp., illus. U.S. $11.

The grizzly. 1984. By Jerolyn Ann Nentl. Crestwood, Mankato, Minnesota. 47 pp., illus. U.S. $8.95.

Lemurs. 1984. by Norman D. Anderson and Walter R. Brown. Dodd, Mead, New York. 63 pp., illus. U.S. $9.95.

Mountain homes. 1985. By Althea. Cambridge University Press, New York. c24 pp., illus. Cloth U.S. $5.50; paper U.S. $1.95.

The raccoon. 1984. By Jerolyn Ann Nentl. Crestwood, Mankato, Minnesota. 47 pp., illus. U.S. $8.95.

Rainforest homes. 1985. By Althea. Cambridge University Press, New York. c24 pp., illus. Cloth U.S. $5.50; paper U.S. $1.95.

Rattlesnakes. 1984. By Earl G. Chace. Dodd, Mead, New York. 64 pp., illus. U.S. $7.95.

Rock collecting. 1984. By Roma Glans. Crowell, New York. 28 pp., illus. U.S. $11.50.

Scavengers and decomposers: the cleanup crew. 1984. By Pat Hughley. Atheneum, New York. 56 pp., illus. U.S. $11.95.

The sea world book of sharks. 1984. By Eve Bunting. Harcourt Brace Jovanovich, New York. 79 pp., illus. U.S. $6.95.

Undersea homes. 1985. By Althea. Cambridge University Press, New York. c24 pp., illus. Cloth U.S. $5.50; paper U.S. $1.95.

The wild cats. 1984. By Jerolyn Ann Nentl. Crestwood, Mankato, Minnesota. 47 pp., illus. U.S. $8.95.

Wonders of sharks. 1984. By Wyatt Blassinggame. Dodd, Mead, New York. 96 pp., illus. U.S. $9.95.

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Advice to Contributors

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Manuscripts

Please submit, in either English or French, three complete manuscripts written in the journal style. The research reported should be original. It is recommended that authors ask qualified persons to appraise the paper before it is submitted. Also authors are expected to have complied with all pertinent legislation regarding the study, disturbance, or collection of animals, plants or minerals. The place where voucher specimens have been deposited, and their catalogue numbers, should be given. Latitude and longitude should be included for all individual localities where collection or observations have been made.

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The **Council of Biology Editors Style Manual**, 4th edition (1978) available from the American Institute of Biological Sciences, is recommended as a guide to contributors. **Webster's New International Dictionary** and le **Grand Larousse Encyclopédique** are the authorities for spelling.

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TABLE OF CONTENTS *(concluded)*

Mailing date of the previous number (Volume 99, Number 4): 11 April 1986

THE CANADIAN FIELD-NATURALIST Volume 100, Number 1 1986

Articles

The Biological Flora of Canada

Notes

concluded on inside back cover

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Cover: Mongolian Plover, *Charadrius mongolus*, observed in June 1984 north of Fort McMurray, Alberta. Photograph by W. R. Koski. *See* Salter, Smith, Koski, and Barbeau, pages 257–258.

The Canadian Field-Naturalist

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Movements and Home Range of Porcupines, *Erethizon dorsatum*, in Idaho Shrub Desert

ERICA H. CRAIG[1] and BARRY L. KELLER

Department of Biological Sciences, Idaho State University, Pocatello, Idaho 83209
[1]Present address: Box 1, Lee Creek Road, Leadore, Idaho 83464
Please address reprint requests to either author, c/o Department of Biological Sciences, Idaho State University, Pocatello, Idaho 83209

Craig, Erica H., and Barry L. Keller. 1986. Movements and home range of Porcupines, *Erethizon dorsatum*, in Idaho shrub desert. Canadian Field-Naturalist 100(2): 167-173.

Biotelemetry and direct observation were used to study movements and home range size of Porcupines (*Erethizon dorsatum*) in a desert-shrub environment in southeastern Idaho. Winter movements were found to be significantly less than those in spring and summer, probably as a result of seasonal food availability and/or weather. Home range size (modified minimum area method) averaged 0.07 ± 0.07 ha for two Porcupines monitored from January through March 1976. Spring and summer home range size averaged 23.1 ± 12.4 ha for seven females and was 61.7 ha for one male. Movements and home range size generally were smaller than those reported in forested habitats in the western United States.

Key Words: Porcupine, *Erethizon dorsatum*, Idaho, telemetry, movement.

The Porcupine, *Erethizon dorsatum*, occurs in a wide variety of habitats within its range in Alaska, Canada, and the western half of the United States. Most investigators have sought data on Porcupines in wooded habitats (Krefting et al. 1962; Kivisalu 1966; Dodge and Barnes 1975; Smith 1979) perhaps largely because of the impact of this rodent on forests being managed for production of wood products. The paucity of similar data in desert-shrub environments prompted our study of an Idaho population.

Study Area

The study area is situated southeast of Pocatello, in portions of Bannock and Power counties (approximately 42°45′N, 112°20′E). The terrain is characterized by steep, rolling hills that range in elevation from 1525 to 2089 m and is dissected by numerous small creeks and dry ravines. Generally, the weather of the locale is characterized by hot summers and cold winters. The least amount of precipitation as well as the highest temperatures (32-37°C during July and August) occur during the summer. Total precipitation in water equivalents during the study was 28.1 cm. From January through April, 103.1 cm of snow was recorded at the nearest weather station (42°55′N, 112°36′W).

The vegetational pattern within the study area is heterogeneous with four communities represented (see Table 1). The dominant Big Sage vegetational association is almost identical to the Big Sage-Utah Juniper community that occurs primarily on south-facing slopes. River Hawthorn-Chokecherry habitat is most commonly found along stream banks, whereas the Quaking Aspen association, although it is found in ravines, hollows and other moist areas, is not necessarily found in conjunction with running water.

In the more southerly part of the study area there were scattered Douglas Fir (*Pseudotsuga menziesii*) in Quaking Aspen and River Hawthorn-Chokecherry communities. Douglas Fir, however, was not a major component of the habitats.

Methods and Materials

Field work was conducted from January through October 1976. Most movement data were collected telemetrically, although winter movements were determined largely by visual observations.

A few animals were collected in Havahart live traps, but most individuals were captured when sighted during the night along the main road of the study area. Animals were captured with a plastic 20 gal. garbage can or by hand and were tranquilized with a mixture of ace-promisine and ketamine hydrochloride (1: 0.1 cc, ketamine : ace-promisine/kg of body wt.) injected intramuscularly. Immobilized animals were tagged with coded metal ear tags, weighed, measured, and fitted with transmitters. Sex was determined, and eruption and wear patterns of the teeth (Kochers-

TABLE 1. Vegetational communities represented on Porcupine study area, southeastern Bannock and Power counties, Idaho.

Plant community	Dominant species	Common species
Big Sage	Big Sage (*Artemisia tridentata*)	Bitterbrush (*Purshia tridentata*), Cheat Grass (*Bromus tectorum*), Bluebunch Wheatgrass (*Agropyron spicatum*), Arrowleaf Balsamroot (*Balsamorhiza sagittata*), Foothill's Death Camas (*Zigadenus paniculatus*).
Big Sage-Utah Juniper	Big Sage, Utah Juniper (*Juniperus osteosperma*)	Same as in the sagebrush plant community.
River Hawthorn-Chokecherry	River Hawthorn (*Crataegus douglassi*), Chokecherry (*Prunus virginiana*)	Wild Rose (*Rosa woodsii*), Red-osier Dogwood (*Cornus stolonifera*), Service Berry (*Amelanchier alnifolia*), Snowberry (*Symphoricarpos oreophilus*), Sticky Geranium (*Geranium viscosissimum*), Hound's Tongue (*Cynoglossum officinale*), willow (*Salix* spp.), bluegrass (*Poa* spp.), Spring Beauty (*Claytonia lanceolata*), Starflower (*Lithophragma bulbifera*).
Quaking Aspen	Quaking Aspen (*Populus tremuloides*)	Golden Currant (*Ribes aureum*), Rocky Mountain Maple (*Acer glabrum*), Service Berry, Wild Rose, False Solomon's Seal (*Smilacina racemosa*), Lily of the Valley (*S. stellata*), Sticky Geranium, lupine (*Lupinus* spp.), Mountain Lover (*Pachistima myrsinites*), Wild Rye-Grass (*Elymus glaucus*).

berger 1950; Dodge 1967) were used to assign animals to broad age categories (juvenile, young adult, adult). Following recovery from the drugs (0.5 to 5.0 h), Porcupines were released at the site of capture.

To ensure minimal effect of the 120 g transmitter package, only animals for which the back pack radio and harness comprised 1.8% or less of the total body weight were instrumented (Brander and Cochran 1969). However, we collected weight, sex and age data on all Porcupines captured and these results are presented in the tables. In addition to the radio-location data, two Porcupines (1 and 2) were monitored by visual observation during the winter for 96 tracking days. Fixes generally were taken during daylight hours and on a daily basis (Table 2). Equipment failure and/or difficulty in locating animals in the rough terrain kept us from obtaining sufficient data for analysis on five Porcupines. Locations were plotted on topographic maps or on aerial photographs. Home range size was determined by the minimum area method (Mohr 1947; Layne 1954), modified minimum area method (Harvey and Barbour 1965), and the relief-adjusted method (Craig 1981), and then measured with a compensating polar planimeter. Data were analyzed seasonally and lumped into spring-summer (late-March to mid-September), fall (late September to October) or winter (January to March).

Results and Discussion

Weights

There was no significant difference in the mean weight of five adult males and the seven adult females (group comparison, t, $p < 0.05$). Female weights appeared to be more variable than male weights, and the extremes (6.8 kg; 15.0 kg) for adults occurred in this group. The lightest female had heavily worn teeth and white hair on the head and chest, an assumed indication of extreme old age (Brander 1971). Porcupines in our study weighed more than most individuals (including animals from other western states) reported in the literature (Table 3).

Movement and Home Range Size

Of the fifteen animals monitored, eight produced sufficient data to estimate spring-summer home range size. Two Porcupines provided sufficient data to estimate winter home range size (observation area curve: Odum and Kuenzler 1955; Ables 1969) (Table 4). We found that the minimum area method required more fixes to calculate home range (> 20) in our study than the modified minimum area method (< 15). In addition, home ranges computed by the modified minimum area method were significantly smaller than those calculated for the minimum area method (group comparison, t, $p < 0.05$) and there was also a significant difference in the home range size in areas of

TABLE 2. Summary of tracking periods and data obtained from thirteen radio-collared Porcupines and two Porcupines (1 and 2) monitored by direct observation.

Animal number	Sex	Age group	Initial tracking period	End of tracking period	Average interval between fixes (days)	Number of fixes obtained
A-3	M	J[1]	4-04-76	4-09-76	0.71	7
A-4	F	AD[2]	4-05-76	5-30-76	1.18	22
A-5	F	AD	4-14-76	4-17-76	0.75	4
A-6	M	AD	7-12-76	7-17-76	0.83	6
A-8	F	AD	7-19-76	10-14-76	2.29	38
A-10	F	AD	7-26-76	9-10-76	2.09	22
A-11	F	AD	7-27-76	9-19-76	1.80	25
A-12	M	AD	7-28-76	10-08-76	2.40	30
A-13	F	AD	8-04-76	10-14-76	2.82	26
A-14	M	AD	8-04-76	8-22-76	—	2
A-15	F	YAD[3]	8-05-76	8-25-76	0.87	23
A-16	M	AD	8-10-76	10-08-76	—	2
A-18	F	AD	8-11-76	8-31-76	1.05	19
1	—	—	1-20-76	3-01-76	2.05	20
2	—	—	1-07-76	3-15-76	2.12	26

[1]J: juvenile.
[2]AD: adult.
[3]YAD: young adult.

elevational differences when the relief-adjusted method and the modified minimum area method were compared (pairing design, t, $p < 0.05$). These results emphasize the problem that arises in comparing home range data from studies in which the method of computation is unreported or where elevational changes, which affect home range size (Craig 1981), are not considered.

Dodge (1967) and Smith (1975) reported no differences in distances moved by males and females or among age classes in Porcupines and our values also appeared to be similar, so we combined our movement data among age classes for subsequent analyses.

Fall and Winter

Smith (1975) reported fall movements of Porcupines to be markedly less than summer movements, probably as a result of the decreased availability of green vegetation. He noted this decline occurred as early as the end of July. Although we obtained limited data (9 fixes) during fall, movements of our individuals did not appear to be less than those observed during summer (Table 5: A-12 and A-13).

In contrast to the reports in the existing literature, the Porcupines in our study area remained in the tops of hawthorn thickets for the duration of the winter and no more than two animals were observed in close proximity. Most investigators have reported that Porcupines use dens during winter months for protection from weather (Shapiro 1949; Kivisalu 1966; Dodge 1967; Randall 1971; Smith 1975; Speer and Dilworth 1978). Shapiro (1949), Kivisalu (1966), and Dodge (1967) also observed congregations of animals at den sites. Smith (1979) reported an individual that stayed in a tree for 16 days during winter in wooded habitat and similar behavior has been reported by Brander (1973) in a hardwood-hemlock forest.

The two Porcupines we monitored were never seen in the same tree at the same time, but their home ranges did overlap slightly. Throughout the winter we never observed them in these thickets on the ground and no tracks were seen in the snow around their feeding areas. In thicket areas, individuals we observed fed solely upon hawthorn which was severely damaged by spring. Hawthorn thickets in which we observed animals had been used previously by wintering Porcupines for at least four consecutive winters.

Animals fed primarily on twigs in the canopy of the thicket rather than on the main trunks of shrubs. The pruning effect, similar to that described for other trees by Gabrielson (1928), Curtis (1941) and Smith (1975), increased the density of branches in the thicket, and the efficiency of the area as a windbreak for protection from inclement weather appeared to be enhanced. Gill and Cordes (1972) noted a similar use of isolated stands of Limber Pine (*Pinus flexilis*) in the southern Alberta foothills. Not all individuals in the study area occupied thickets, however. We found limited sign that Porcupines in part of the study area fed upon

TABLE 3. Comparison of Porcupine weights reported by investigators.

Weights (kg) $\bar{x} \pm$ S.D.	Location	Reference
11.5 ± 1.5 (5 adult males)[1]	Idaho	This study
9.8 ± 2.9 (7 adult females)		
5.9 ± 1.2 (2 young adults)		
3.5 ± 2.9 (5 juveniles)		
3.2 (4 animals)	Oregon	Smith 1975
5.9 (3 males)	Nevada	Randall 1971
7.0 (2 females)		
9.1 (7 adult males)	Oregon	Gabrielson 1928
6.0 (9 adult females)		
5.3 (28 adult males)	Massachusetts	Dodge 1967
5.0 (32 adult females)		
4.5 (4 animals)	Massachusetts	Kivisalu 1966
5.9 (7 males)	New York	Shapiro 1949
4.6 (9 females)		
5.7 (4 males)	Maine	Curtis and Kozicky 1944
4.9 (5 females)		

[1]All individuals captured were measured; hence, more Porcupines are reported here than in tables with tracking results.

Red-osier Dogwood, willow, Wild Rose and Douglas Fir.

The mean distance Porcupines 1 and 2 moved during the winter (January through March) ($\bar{x}$ = 7.0 ± 9.6 m) is comparable to that found by Brander (1973) in Michigan (7.4 m), but is much smaller than values reported by other investigators: 132 m (Shapiro 1949), 832 m (Krefting et al. 1962), and 92 m (Dodge 1967). The average winter home range (0.10 ± 0.11 ha: minimum area method and 0.07 ± 0.07 ha: modified minimum area method) for the two Porcupines was smaller than that reported by Shapiro (1949), who found home range size from mid-February through the end of March in New York to be 5.4 ha (method of calculation not stated) and Smith (1979), who described home range areas of two Porcupines in Oregon during the months of January and February to be 3.9 and 8.1 ha (minimum area method). The restricted winter movements and small home range size for Porcupines in our study probably resulted from lack of movement by individuals to and from dens to feed and from the presence of adequate shelter and food in hawthorn thickets.

Spring and Summer

During the spring (end of March through May) animal movements were greater than those during the winter months. This increase in movements began with the appearance of succulent vegetation in early spring when Porcupines moved from tree tops to feed on the ground. Smith (1979) also found that Porcupine movements in spring increased over winter movements. We found no significant difference between spring and summer movements (group comparison, t, $p > 0.05$) so these data were lumped and contrasted with those in the winter (Table 5).

There was a significant difference between winter and spring–summer movement patterns, similar to reports by Gabrielson (1928) and Smith (1979). Spring–summer movements were meandering and erratic, resulting in mean movements that were smaller than their standard deviations. The mean distance (excluding winter) traveled by Porcupines that were located more than four times (152 m between radio locations) was less than that reported in other western habitats with the exception of values reported by Hoffer (personal communication *in* Smith 1979) in northern California (144 m) where animals purportedly fed in alfalfa fields during the summer. Randall (1971) reported mean distance between captures for the spring and summer to be 490 m in Nevada. Smith (1979) reported a yearly average movement value of 238 m (Oregon) and Dodge and Barnes (1975) reported a 273 m yearly average (northern Washington). The maximum distances travelled between locations were generally less during our study than those reported by Smith (1979) (range: 0 to 2632 m) and Randall (1971) who reported summer movements for telemetered animals ranged from 0 to 1595 m. Studies in hardwood forests yielded mean summer movements of 150 m (Brander 1973) and approximately 200 m for two animals

TABLE 4. Home range size calculated by three methods for 13 Porcupines studied in southeastern Idaho. Length and width are indicated in meters and area in hectares.

Animal number	Sex	Minimum Area Method			Modified Minimum Area Method			Relief-Adjusted Method
		Width	Length	Total area	Width	Length	Total area	Total area
A-3	M	158 (36)	794(180)[1]	6.9	15 (0)	15 (0)	0.2	nd[2]
A-4*	F	396(168)	839(264)	23.9	203(48) 102(84)	248 (0) 272(132)	5.4	10.1
A-5	F	317 (12)	665(108)	3.3	15 (0)	15 (0)	0.2	nd
A-6	M	238 (12)	810 (48)	11.6	79 (0)	124 (0)	1.4	nd
A-8*	F	364 (60)	832 (60)	19.6	272(24)	396 (36)	9.4	10.1
A-10*	F	854(108)	1566(192)	43.8	356(24) 150(12)	356 (84) 808 (60)	4.7	5.4
A-11*	F	269 (72)	1663(168)	27.9	162(61) 15 (0)	430 (49) 377 (0)	8.3	nd
A-12*	M	808(204)	1980(336)	99.3	333(36)	1426(192)	61.6	65.6
A-13*	F	539 (60)	950(144)	28.9	40 (0)	396 (0)	14.9	nd
A-15*	F	294 (0)	523(132)	9.1	99 (0)	356 (24)	3.3	4.4
A-18*	F	158 (36)	792 (72)	8.3	158(18)	475 (24)	4.3	5.4
1*	—	10 (0)	25 (0)	0.02	10 (0)	25 (0)	0.02	nd
2*	—	35 (0)	82 (0)	0.18	23 (0)	83 (0)	0.12	nd

[1]Elevational changes in meters that occurred for width and length of the home range.
[2]nd = no measurable difference in home range size as contrasted to adjacent column.
*Porcupines that we believe were relocated a sufficient number of times to estimate home range size.

monitored for a 30-day period (Marshall et al. 1962).

Average home range size of the adult female Porcupines in our study (minimum area method: 23.1 ± 12.4 (SD) ha; modified minimum area method: 7.2 ± 4.0 ha; relief-adjusted method: 8.4 ± 4.0 ha) was much smaller than that of the single adult male for which we could calculate home range (99.3, 61.6 and 65.6 ha, respectively: Table 4). This difference may not be significant as we are unable to ascertain whether this individual displayed vagrant movements (Harder 1980). Smith (1979) reported minimum home range areas for four female Porcupines in the spring and summer to be 22.6, 28.8, 80.8 and 82.1 ha ($\bar{x}$ = 53.6 ha). Dodge and Barnes (1975) also had much larger home range values (81.2 ha: minimum area method) than we found in our study. Four Porcupines radio-tracked in northern California by Hoffer (personal communication *in* Smith 1975) yielded a home range size of 216 ha (method of calculation not stated) and Marshall et al. (1962) in Minnesota, reported summer home ranges for two female Porcupines to be 13.0 and 14.6 ha (method of calculation not stated).

Smith (1979) found that minimum and maximum movements were comparable to minimum and maximum widths and lengths of the home range areas. Our comparisons showed only that maximum distances fell within the home range length and width but were not necessarily comparable. In addition, there was no significant correlation between porcupine weights in our study and maximum movements or home range size.

Habitat Utilization

Although the sagebrush habitats dominated our study area, Porcupines appeared to select the less dominant Quaking Aspen and River Hawthorn-Chokecherry habitats (270 out of 280 spring and summer locations). Our data did not indicate, however, that the animals preferred the aspen over the hawthorn association, or vice versa. (Clopper and Pearson Chart for confidence belts of proportions, $p > 0.05$.) Animals tended to select brush habitats in which there was a variety of green plants throughout the summer.

When home range size was computed by the modified minimum area method, it was found that the boundaries coincided with preferred vegetational

TABLE 5. Mean movements in meters ± SD, and range of values ( ), for 13 Porcupines in southeastern Idaho as determined by telemetry and by direct observation.

Animal number	Sex	Fall and winter	Spring-summer
A-3	M	—	193 ± 255 (0 − 648)
A-4	F	—	118 ± 140 (3 − 648)
A-5	F	—	224 ± 387 (0 − 670)
A-6	M	—	209 ± 280 (3 − 567)
A-8	F	6 ± 3 (3 − 9)	81 ± 107 (3 − 486)
A-10	F	—	219 ± 277 (15 − 889)
A-11	F	—	154 ± 215 (15 − 972)
A-12	M	697 ± 70[1] (648 − 746)	242 ± 271 (15 − 972)
A-13	F	171 ± 227[1] (15 − 509)	186 ± 198 (15 − 708)
A-15	F	—	239 ± 160 (15 − 243)
A-18	F	—	142 ± 140 (15 − 567)
1	—	6 ± 7 (0 − 25)	—
2	—	8 ± 11 (0 − 45)	—

[1]Fall movements data — indicates no data or insufficient data for this time period.

communities. Furthermore, several home range plots appeared to be split into two areas joined by a narrow corridor. Where this occurred, the major portions of the home range encompassed brushy habitat in which individuals were usually located. Smith (1979) also noticed the tendency of Porcupines to remain in certain habitats and suggested that outlining habitat types between locations might more accurately depict home range areas.

The restricted movements and relatively small home range areas, in conjunction with the large size of the Porcupines in this study, may indicate that an abundance of food allows desert-shrub Porcupines to remain within a smaller area than animals in forest regions in the west. Randall (1971) noted that Porcupines will often frequent sub-climax or marginal zones where a variety of ground vegetation predominates. Our study area, with its numerous draws and creek bottoms, probably offered a greater diversity of vegetation than forest communities.

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Strandings of Sperm Whales, *Physeter catodon*,* in Ungava Bay, Northern Québec

RANDALL R. REEVES,[1] KERWIN J. FINLEY,[2] EDWARD MITCHELL,[1] and JOHN MACDONALD[3]

[1]Arctic Biological Station, 555 St Pierre Blvd, Ste-Anne-de-Bellevue, Québec H9X 3R4
[2]LGL Limited, environmental research associates, Suite 333, 2453 Beacon Avenue, Sidney, British Columbia V8L 1X7
[3]Cultural and Linguistics Section, Department of Indian and Northern Affairs, Ottawa, Ontario K1A 0H4

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The first reported occurrences of strandings, supported by specimens and detailed descriptions, of Sperm Whales, *Physeter catodon*, in Ungava Bay are based on at least three strandings that took place between 1969 and 1981. These strandings of adult males fall within the extreme limits of the subarctic biogeographic zone and provide evidence of the northwestern limit of the Sperm Whale's range in the North Atlantic.

Key Words: Sperm Whale, *Physeter catodon*, *Physeter macrocephalus*, stranding, Ungava Bay.

In summer 1969 Inuit hunters from George River, Québec, reported that a very large whale, of a species never before seen by them, was lying dead on the beach several kilometers southwest of Cape Kernertut on Ungava Bay, at approximately 58°30′N, 67°00′W (Figure 1; Record No. 1). The Inuktitut designation of the site is Pitsiulaqsiti. MacDonald, who was living at George River at the time, discussed the stranding with the hunters and queried the whale's identity. The hunters insisted that it was not an *arviq*, as the Bowhead or Greenland whale, *Balaena mysticetus*, is known locally. The bowhead is the only large cetacean that had been documented previously in Hudson Bay and Hudson Strait (Turner 1888: 83; Gordon 1887: 60–64; Wakeham 1898: 74–76; Sergeant 1968; Finley et al. 1982).

In summer 1970 John and Carolyn MacDonald visited the site and identified the remains as those of a Sperm Whale, *Physeter catodon* (Figure 2). The total length of the badly decomposed carcass was approximately 17.7 m (58 ft). Its size positively identifies the whale as an adult male; this is consistent with the fact that females and young seldom occur polewards of temperate latitudes (Best 1979). The carcass probably had been on the beach since at least the previous summer. Many of the large, conical teeth were recovered from shallow pools nearby, where they had been strewn by wave action after falling out of the exposed mandibles. Carvings were later made from these teeth by George River artists (Iglauer 1979: 215; Anonymous 1982).

*Although the editorial policy of the International Whaling Commission currently requires the use of *P. macrocephalus* in place of *P. catodon*, we accept the reasoning of Watkins and Moore (1982: 1*n*) and continue to use *catodon* as the more appropriate designation.

The presence in the vicinity of another stranded whale (Figure 1; Record No. 2), thought to be of the same species, was mentioned to the MacDonalds. Unfortunately, they had no opportunity to confirm this at the time, and the exact position of the second animal was not determined. During 1980, Finley acquired corroborative information from older hunters in Fort Chimo, who regularly hunted in the vicinity of Cape Kernertut, that two Sperm Whales had stranded in the same area in southern Ungava Bay at this earlier time.

In addition, Johnny May, operator of a charter air service in Fort Chimo, told Finley that he recalled seeing the carcass of a large whale on a small island near the east coast of Ungava Bay approximately 15-20 km south of Port Burwell (Figure 1; Record No. 3). It was first observed in about 1969, and May witnessed the slow degradation of the carcass over the next three or four years during his many flights between Port Burwell and Fort Chimo. The existence of this whale was corroborated independently during an interview Finley conducted with George Koneak, a hunter who originally lived at the now-abandoned settlement of Port Burwell. Koneak remembered visiting the carcass on the island and stated that it was a large whale like a Bowhead but that it had large, fist-sized teeth, some of which were taken and used for carving.

On the basis of the above evidence, we believe there were at least two, and probably three Sperm Whales stranded in Ungava Bay in approximately 1969. Thus, a possible multiple stranding or die-off of Sperm Whales in about 1969 is suggested.

What is apparently the fourth record (third, or fourth carcass) of a Sperm Whale stranding in Ungava Bay was reported to Finley in June 1981. A large

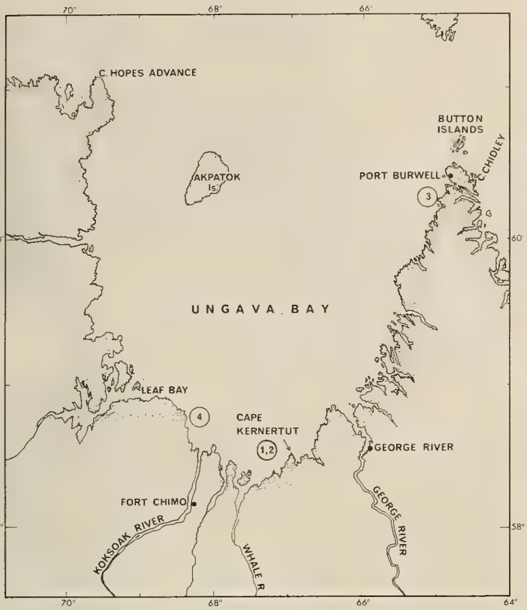

FIGURE 1. Map of Ungava Bay, showing place names mentioned in the text. Numbers in circles refer to specimens described in the text.

FIGURE 2. Antero-dorsal view of the large male Sperm Whale at Pitsiulaqsiti (Cape Kernertut), summer 1970. The whale's blowhole, clearly seen in the right foreground, permits positive identification, as the Sperm Whale is the only cetacean with the blowhole situated at the left front edge of the blunt snout.

whale was discovered by Mark Elijahpik of Fort Chimo on the ice 3.8 km south of Ragged Point (58°47′N, 68°23′W) in early spring 1981 (Figure 1; Record No. 4). C. Drolet investigated this stranding for us on 7 July 1981 (Figure 3). He noted that the whale was a dark colour with a whitish belly (or genital area?). Its penis was protruding. Drolet measured this male Sperm Whale at 16.8 m in total length, and he collected two mandibular teeth from near the center of the jaw (Figures 4 and 5). Considering the condition of the carcass, we suspect the whale's length was actually somewhat less. Other measurements are shown in Table 1.

The more complete tooth (EDM 1000-10183) was sectioned longitudinally and etched in a bath of 10% formic acid by V. M. Kozicki (procedures outlined in Perrin and Myrick 1980: 42). We counted 32–42 growth layer groups (terminology of Perrin and Myrick 1980) in the tooth.

We have no confirmed records of live Sperm Whales in Ungava Bay, although residents of George River claim to see large whales during late fall whose blows come out of the head at an angle and to the side, which is characteristic of Sperm Whales (Sandy Gordon, personal communication to Reeves, 27 October 1981). The stranded whales could have died far from their stranding sites and simply drifted ashore. This is unlikely, however, because the current flows west to east through Hudson Strait, with a counterclockwise intrusion of Hudson Bay water into Ungava Bay (Dunbar 1951). To reach the southeast part of Ungava Bay, the whales that stranded there would have had to move against the current (estimated at 9 cm/s, surface velocity, by Dunbar 1951).

The *Calanus* expeditions to study the marine fauna

TABLE 1. Measurements made by C. Drolet of a stranded male Sperm Whale near Ragged Point, Ungava Bay, on 7 July 1981.

	Length (cm)
Total body	1680
Tip of snout to tip of lower jaw	100
Tip of snout to center of blowhole	80
Tip of snout to dorsal fin (hump)	1060
Depth of fluke	120
Width of flukes	200x2
Number of teeth in lower jaw: 23x2	

FIGURE 3. Carcass of Specimen No. 4, at Ragged Point, 7 July 1981. Inset shows area of jaw from which teeth were removed for age determination. Photographs courtesy of C. Drolet.

of Ungava Bay from 1947 to 1950 were concerned primarily with the distribution of fishes, annelids, echinoderms, amphipods, and copepods (Dunbar 1956). Consequently, we do not know if concentrations of large bathypelagic and mesopelagic squid, the principal prey of bull Sperm Whales in the southern hemisphere (Best 1979), occur there. Roe (1969) found that the bull Sperm Whales caught in Denmark Strait by Icelandic whalers eat mainly fish, the commonest species being lumpsuckers (*Cyclopterus lumpus*), redfish (*Sebastes* sp.), and angler fish (*Lophius piscatorius*). Dunbar and Hildebrand (1952) documented a variety of fish species in Ungava Bay, but it is unclear from their description of methodology whether the depths at which Sperm Whales are known to feed (on the sea bottom at least to 500 m, according to Roe 1969) were sampled.

Although cetacean distribution along the coast of Labrador is poorly documented, there are several published statements that Sperm Whales occur inshore in northern Labrador (Bangs 1909: 459; Williamson 1964: 21; Weiz and Packard 1866: 266, 271). Sergeant (1961: 5) claimed, without citing his source or any data, that "herds of bulls, of fairly uniform size (40 to 60 ft), travel northward in loose groups which reach at least to mid Labrador in summer." A large Sperm Whale is said to have washed ashore at Tesialuk Bay, south of Makkovik, one autumn during the 1940s, and local hunters claim to have seen a live Sperm Whale in this area during the same period (C. Brice-Bennett. 1980. An overview of the occurrence of cetaceans along the Labrador coast. Unpublished report in fulfillment of Contract No. OTT78-111 for the Department of Indian Affairs and Northern Development, Ottawa. 34 pp.). Another stranding of an adult male near Black Island, northeast of Nain, in early November "about 20 years ago" and sightings in Okak Bay and off Cape

FIGURE 4. Frontal view of intact tooth from Ragged Point (Specimen No. 4). The chip marks were made during removal. The broken tip, however, may have been the "normal" condition in the living whale. Drawing by G. Ferrand. (Tooth EDM 1000-7VII81.)

FIGURE 5. Etched half-section of tooth from Ragged Point (Specimen No. 4), showing layering used for age determination. (Tooth EDM 1000-10183.)

Kiglapait during August and September 1977 have been reported by local hunters (C. Brice-Bennett, see above). A large Sperm Whale was sighted about 55 km off the east coast at latitude 60° N, longitude 63°03′W, swimming east on 11 September 1977 (J. H. Allen and S. A. M. Conover. 1978. Report on aerial surveys 77-2, 77-3, 77-4. Studies of seabirds and marine mammals in Davis Strait, Hudson Strait and Ungava Bay. Unpublished report by MacLaren Atlantic Limited for Imperial Oil Ltd., Aquitaine Co. of Canada Ltd. and Canada Cities Services Ltd., Arctic Petroleum Operators Association Project No. 134 and 138, December 1977.).

According to Mitchell (1974: 155), bull Sperm Whales migrate along the continental slope off eastern Canada, and "pods have been observed feeding on the slope as far north as Cape Chidley on the Labrador coast."

Clark's (1887) chart showing world whaling grounds of the nineteenth century indicates a Sperm Whale concentration at the mouth of the Strait of Belle Isle, but none farther north. Low (1906: 273) referred to several large mysticetes in addition to the bowhead occurring in southern and eastern Davis Strait, but he did not mention the Sperm Whale. He was of the opinion that no species of large whale other than the bowhead was to be found in the "densely ice-covered seas of the western side, nor are they found in Hudson strait or bay." Sperm Whales have been seen and caught off West Greenland as far north as latitude 68° N (Hjort and Ruud 1928; Kapel 1979; Whitehead et al. 1982).

Sperm Whales were caught infrequently by whalers operating out of land stations in southeast Labrador, Newfoundland, and Nova Scotia (Mitchell 1974). Body length data for 273 of the 414 Sperm Whales reportedly caught in the Newfoundland/Labrador whale fishery from 1904 to 1963 gave a mean length of 14.4 m (Mitchell and Kozicki 1984). A sample of 109 Sperm Whales landed at the Blandford, Nova Scotia, whaling station between 1964 and 1972 proved to consist almost entirely of sexually mature bulls, with a mean body length of 1368 cm ± 163 cm (Mitchell and Kozicki 1984). The largest individual in either sample was 18 m long.

The records reported here are the first evidence of Sperm Whales occurring in Hudson Strait or Ungava Bay. They are not unexpected, since males are known

to range in summer almost to the limits of the subarctic marine zone as defined by Dunbar (1972). Ungava Bay is included within this biogeographic zone and contains faunal elements reflecting the influence of subarctic waters of the Northwest Atlantic. The Northern Bottlenose Whale, *Hyperoodon ampullatus*, a deep-diving teuthophage like the Sperm Whale, is found regularly at the mouth of Hudson Strait during May through July (Gordon 1887: 63; Mitchell and Kozicki 1975).

There is by present accounting only one wide-ranging stock of Sperm Whales in the North Atlantic (Mitchell 1975), so data from the recent whale fishery at Iceland may be pertinent. The largest specimen in Martin's (1980) sample of Sperm Whales from Iceland was 57 ft (17.37 m) long and was judged to be 32 growth layer groups old.

Acknowledgments

We thank Carolyn MacDonald for data on the Cape Kernertut whale(s) (Record Nos. 1-2), C. Drolet for examining and sampling the Ragged Point specimen (Record No. 4) at our request, and M. Allard for confirming the localities of the strandings. G. Horonowitsch, A. Evely, and V. M. Kozicki provided technical support. Cooperation from residents of the Ungava region, especially Johnny May, Sandy Gordon, George Koneak, and Mark Elijahpik, is also gratefully acknowledged.

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Summer Birds of East Bay, Southampton Island, Northwest Territories

Kenneth F. Abraham[1] and C. Davison Ankney

Department of Zoology, University of Western Ontario, London, Ontario N6A 5B7
[1]Present address: Ministry of Natural Resources, P.O. Box 190, Moosonee, Ontario P0L 1Y0

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Forty-one species of birds were observed in the summers of 1979 and 1980 along the south shore of East Bay, Southampton Island. The first certain evidence was obtained of Red Knot (*Calidris canutus*) and Sanderling (*Calidris alba*) nesting on Southampton Island. The abundance of several species, particularly Common Eider (*Somateria molissima*) and Whimbrel (*Numenius phaeopus*), differed from the other Southampton Island locations where birds have been studied. No species new to the island were recorded.

Key Words: Nesting, abundance, Southampton Island, Northwest Territories, *Calidris canutus*, Red Knot, *Calidris alba*, Sanderling.

The avifauna of Southampton Island has been described by Sutton (1932), Bray (1943) and Parker and Ross (1973). Only Sutton (1932) included data from the eastern third of the island which is geomorphologically distinct (Parker 1975). East Bay is a significant feature of this portion and the East Bay Migratory Bird Sanctuary was established in 1959 to protect a nesting colony of Snow Geese. Geese were studied there by Cooch (1958), Barry (1962) and Kerbes (1975). As no intensive investigation had been made of other species in this area, we collected data on birds in the summers of 1979 and 1980 during studies of Brant (scientific names of birds in Table 1). Here we summarize the data for 41 species observed, and discuss in detail several species whose status differed appreciably from that reported previously for Southampton Island.

Study Area and Methods

East Bay (hereafter EB) is a 50 km inlet off Foxe Channel (Figure 1). We had camps on the south shore of EB (63°58′N, 81°50′W) from 4 July to 14 August 1979 and 6 June to 14 August 1980. The south shore of EB rises in a series of well-vegetated terraces separated by raised gravel ridges (former beaches). The lowest terrace is dominated by *Puccinellia phryganodes*, *Carex subspathacea*, and *Saxifraga tricuspidata*. Higher, more inland terraces are sedge-grass communities (*Carex misandra, C. bigelowii, Arctagrostis latifolia, Dupontia fischeri*) dominated in parts by dwarf willow (*Salix* spp.). Mosses are ubiquitous in moist areas and form the edge of most pond basins. The beach ridges are sand overlain by a mantle of relatively fine disintegrated limestone. *Dryas integrifolia* is the major plant on the ridges, with *Saxifraga* spp., *Salix reticulata*, and several lichen species interspersed throughout (see Parker 1975 for photographs and vegetation lists). Large expanses of sparsely-vegetated shattered limestone predominate inland to the southeast. Ponds and small lakes are numerous within 3 km of the bay on the south shore, and 50–70% of the total surface area of the coastal plain is water.

Most of our observations were made within the sanctuary in a 12 km × 3 km strip adjoining the bay. Each day we recorded species seen, numbers of less common species (we did not attept to assess daily the numbers of the ubiquitous species), and notes on migrations, nesting and other behavior. We systematically searched some areas for all goose nests. No attempt was made to search systematically for nests of other species, although we believe that few nests of the conspicuous species (loons and Herring Gulls) were missed. We made brief visits to other areas during the incubation periods of most species: the west end (head) of EB on 16 to 18 July 1979, the unnamed island in EB on 8 and 10 July 1980, and Gore Point on 11 to 13 July 1980 (Figure 1). We also visited Native Bay and the Bay of God's Mercy (on the southwest coast of Southampton Island) including part of the Harry Gibbons Migratory Bird Sanctuary to band moulting geese in August each year.

Results

Forty-one species of birds were recorded at East Bay in 1979 and 1980, of which 25 nested and 6 may have nested. Dates of first observation, frequency of observation, evidence of breeding, and clutch numbers and size are summarized in Table 1 (names and taxonomic order follow the American Ornithologist's Union *Checklist* (1983)).

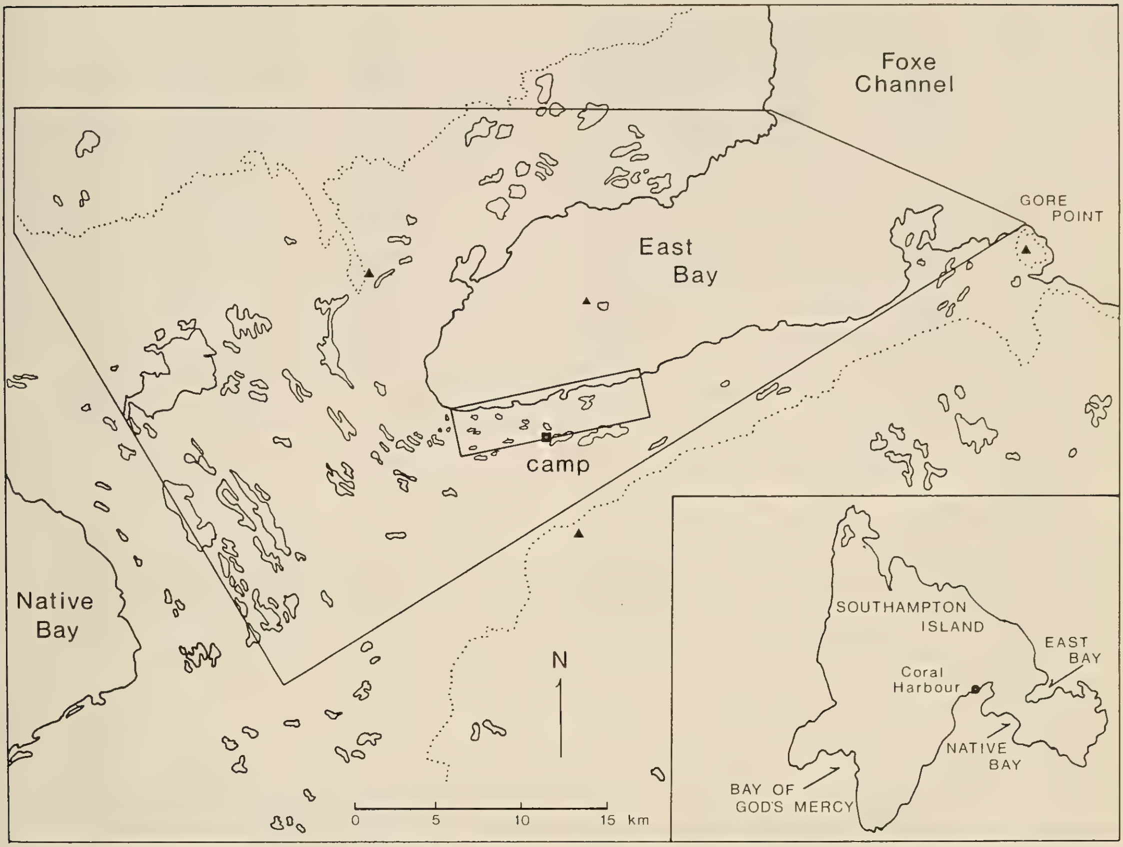

FIGURE 1. East Bay area, showing its position on Southampton Island (inset), East Bay Migratory Bird Sanctuary boundaries (polygon), primary study area (rectangle), locations briefly visited (triangles) and 30.5 m elevation contour (dotted line).

Annotated List

TUNDRA SWAN. No nests were found, but one pair with three downy, flightless cygnets was seen on 18 July 1979. Adults were seen regularly in June and early July 1980 and some aerial displays were noted. Signs of nest building were discovered on 4 July 1980. There were definitely fewer swans at EB than the Bay of God's Mercy.

SNOW GOOSE. The eastern limit of the EB Lesser Snow Goose colony (Kerbes 1975) lies within the western portion of our study area. Nest density increased westward toward the head of EB. Most birds nested on the exposed beach ridges above the first terrace (i.e. above 5 m above the high tide level). After hatching and during the flightless period, they were less common in the study area, dispersing inland towards Native Bay and eastward along the south shore as far as Gore Point (Figure 1). Nesting occurred in both years, but conditions were more favourable in 1979. Hatching was earlier in 1979 (6 to 12 July) than in 1980 (10 to 18 July). Total nesting attempts in the study area in 1979 and 1980, determined by systematic searches during the final 10 days of incubation, were 605 and 71 respectively, an 88% difference. Qualitative aerial observations during supply flights and banding in 1980 revealed very large numbers of Snow Geese in the lowlands between EB and Native Bay, suggesting that in the poorer season when only about 20% of potential breeders nested, the birds still remained to moult within the historical post-hatch feeding areas. Blue-phase geese comprised 38% of two samples of nesting birds (38% in 1979, N = 250; 37.4% in 1980, N = 358). Among flightless (banded) adults and young at EB in 1979 there were 35.7% blue-phase (N = 1092) and at the Bay of God's Mercy in 1979 there were 36.2% blue (N = 1456).

TABLE 1. Birds observed at East Bay, Southampton Island, during the summers of 1979 and 1980.

Species		Date of first observation in 1980[a]	Number of days observed/ Number of days possible after first observation (in 1980)	Evidence of breeding[d]	Clutch Size			
					N	Mode	$\overline{X}$	S.D.
Red-throated Loon	*Gavia stellata*	12 June[c]	57/57	N	35	2	1.69	0.47
Arctic Loon	*Gavia arctica*	14 June[c]	55/55	N	16	2	1.81	0.40
Tundra Swan	*Cygnus columbianus*	16 June[c]	18/53	Y				
Snow Goose	*Chen caerulescens*	[b,c]	63/63	N	246	4	3.46	1.05
Ross' Goose	*Chen rossii*	18 June[c]	1/51	N	1	4		
Brant	*Branta bernicla*	12 June[c]	57/57	N	851	3,4	3.49	1.58
Canada Goose	*Branta canadensis*	7 June[c]	61/62	N	67	5	3.84	1.30
Northern Pintail	*Anas acuta*	16 June[c]	20/53					
Common Eider	*Somateria mollissima*	12 June[c]	25/57	N	267	4	3.39	0.82
King Eider	*Somateria spectabilis*	10 June[c]	59/59	N	67	5	4.55	1.97
Oldsquaw	*Clangula hyemalis*	15 June[c]	53/54	N	8	4	5.50	1.51
Peregrine Falcon	*Falco peregrinus*	14 June	3/55					
Willow Ptarmigan	*Lagopus lagopus*	13 June	4/56	D				
Rock Ptarmigan	*Lagopus mutus*	13 June	10/56	D				
Black-bellied Plover	*Pluvialis squatarola*	13 June[c]	56/56	N	1	4		
Lesser Golden Plover	*Pluvialis dominica*	10 June[c]	11/59	N	1	4		
Semipalmated Plover	*Charadrius semipalmatus*	15 June[c]	54/54	N	5	4	4.0	0.0
Whimbrel	*Numenius phaeopus*	28 June[c]	27/34					
Hudsonian Godwit	*Limosa haemastica*	(31 July 1979)						
Ruddy Turnstone	*Arenaria interpres*	8 June[c]	60/63	N	3	4	4.0	0.0
Red Knot	*Calidris canutus*	13 June[c]	24/56	Y				
Sanderling	*Calidris alba*	21 June[c]	2/48	N	1	4		
Semipalmated Sandpiper	*Calidris pusilla*	12 June[c]	26/57					
White-rumped Sandpiper	*Calidris fuscicollis*	12 June[c]	52/57	N	3	4	4.0	0.0
Baird's Sandpiper	*Calidris bairdii*	12 June[c]	18/57	N	2	4	4.0	0.0
Pectoral Sandpiper	*Calidris melanotos*	(14 July 1979)						
Dunlin	*Calidris alpina*	9 June[c]	38/60	D				
Red Phalarope	*Phalaropus fulicaria*	15 June[c]	54/54	N	6	4	3.67	0.52
Parasitic Jaeger	*Stercorarius parasiticus*	[b,c]	60/63	N	4	2	2.0	0.0
Long-tailed Jaeger	*Stercorarius longicaudus*	12 June[c]	31/57	D				
Herring Gull	*Larus argentatus*	7 June[c]	62/63	N	69	3	2.41	0.75
Thayer's Gull	*Larus thayeri*	11 June	5/58					
Glaucous Gull	*Larus hyperboreus*	18 June[c]	5/51					
Sabine's Gull	*Xema sabini*	10 June[c]	58/59	N	35	3	2.62	0.6
Arctic Tern	*Sterna paradisaea*	12 June[c]	56/56	N	50	2	1.86	0.4

TABLE 1. Birds observed at East Bay, Southampton Island, during the summers of 1979 and 1980 (*concluded*).

	Species	Date of first observation in 1980[a]	Number of days observed/ Number of days possible after first observation (in 1980)	Evidence of breeding[d]	Clutch Size			
					N	Mode	$\overline{X}$	S.D.
Black Guillemot	*Cepphus grylle*	10 July	2/31	N	2	2	2.0	0.0
Snowy Owl	*Nyctea scandiaca*	13 July[c]	2/25					
Horned Lark	*Eremophila alpestris*	12 June[c]	10/57	D				
Common Raven	*Corvus corax*	12 July	1/26					
Lapland Longspur	*Calcarius lapponicus*	8 June[c]	58/61	N	1	4		
Snow Bunting	*Plectrophenax nivalis*	8 June[c]	59/61	N	3	5	5.0	0.0

[a]First observation dates are not presented for 1979 because investigators did not arrive on study area until 4 July; 24 of 35 species were observed in the first week of field work in 1979.
[b]Birds on study area when investigators arrived on 6 June 1980.
[c]Observed in 1979.
[d]N = nest, Y = fledglings or flightless young, D = display or territorial behavior.

ROSS' GOOSE. A goose nest found on 10 July 1979 at EB, containing 4 eggs weighing 61 g, 64 g, 74 g, and 76 g and lined with white down, was probably a Ross' Goose nest. Three adult males and three adult females (two with brood patches) were caught in banding drives at EB on 5 and 6 August 1979. An adult male and three flightless goslings were caught in the Harry Gibbons sanctuary on 17 and 19 August 1979.

BRANT. Atlantic Brant arrived and nested latest of the three common goose species (Table 1). Most nested between the high tide line and the first terrace (i.e. below 5 m elevation). Within this area, nests were more numerous toward the head of EB and closer together where mat-forming *Puccinellia* spp. and *Carex* spp. constituted a relatively high percentage of vegetative cover (cf. Barry 1962). Brant were distributed along the entire EB shore after hatching. The number of nests in 1980 (358) was only 21% fewer than in 1979 (455), unlike the 88% drop in Lesser Snow Goose nests. Hatching was 3–4 days earlier in 1979 (12 to 17 July) than in 1980 (15 to 21 July). Few yearlings were observed in 1979 due to low reproductive success in 1978. However, yearlings were widespread throughout the area in 1980 after good reproduction in 1979; they were most common along the inland edge of the nesting zone. Many yearlings moulted at EB in 1980 (estimated 500 birds seen on 4 August). One moulting (flightless) Black Brant (*B. b. nigricans*) female, with a newly refeathered incubation patch, was caught at Native Bay on 11 August 1980.

CANADA GOOSE. Canada Geese were less numerous and more scattered nesters than either Snow Geese or Brant. All nesters were *B. c. parvipes-hutchinsii* (MacInnes 1966) based on egg weights. Egg laying and hatching periods were intermediate between Snow Geese and Brant. Most nests were on mossy islets in larger, more inland ponds but some were on rocky islands of large brackish coastal ponds. Nest distribution overlapped Snow Goose and Brant nesting areas. Canada Goose nesting effort was less in 1980 than in 1979: 27 nests in 1980 vs. 35 in 1979, a 22% difference. We observed some larger Canada Geese (*B. c. interior*?). One pair briefly performed nest-building and showed territorial aggressiveness toward other geese on 23 and 24 June 1980. Two flocks (9 and 10 birds) of large Canada Geese, possible moult migrants, flew northeast over EB on 27 and 28 July 1980. Small Canada Geese were much more common along the shore of Bay of God's Mercy than at EB, and qualitatively seemed to be more common than Brant at Bay of God's Mercy and less common than Brant at EB.

NORTHERN PINTAIL. Pintails were resident throughout both summers, but neither nests nor broods were

found. Our impression is that they were more numerous in 1979 than 1980 (only 129 were observed in 1980). Males predominated in a 1980 sample (40 males : 7 females) and only 3 "pairs" were observed. Most males were in partial eclipse plumage. No certain evidence of pintail nesting on Southampton Island has been found although it was suggested by Sutton (1932), Godfrey (1966) and Parker and Ross (1973).

COMMON EIDER. Although Common Eiders were recorded on only 25 days on the south shore (Table 1), the observations occurred throughout the entire summer and we presume they were continuously present on the nesting island from the time of our first observation on shore. Nesting was recorded only on an unnamed island in EB, but the south shore was used by pairs before nesting and later by broods. Sex ratio in a sample of arriving flocks was 69 males : 65 females, and flocks passed through the study area from south-southwest on a line to the unnamed island. Run-off water from melting snow cut channels in shorefast ice and pairs fed there (ca. 1 pair every 100 m along the shore) on amphipods (*Lagunogammarus* spp.). On our 10 July 1980 visit to the island, we systematically searched small plots in each major habitat and recorded all nests and clutch sizes. Plot size was measured by pacing; the 2 estimates of nest numbers represent pace-lengths of 0.8 and 1.0 m. The estimates were 26-36 nests/ha on rocky beaches, 84–131 nests/ha on moss-*Dryas* ridges with rock and boulder slopes, and 172–272 nests/ha on a moss-*Dryas* plateau (centre of island). Extrapolation based on visual confirmation of nesting over the entire island and the total area of each habitat type gives estimates of total nests between 3800 and 5900. Measurements of 89 eggs in 25 nests suggested that these were *S. m. borealis* rather than *S. m. sedentaria* (L = 73.8 ± S.D. 2.8 mm, B = 48.4 ± S.D. 1.4 mm; cf. Palmer 1976: 59). However, female plumages varied from reddish-brown to very gray (*S. m. sedentaria* females are notably gray, Palmer 1976: 32). Also, adult males with dull yellow bills and more broadly-rounded culmen processes, suggestive of *S. m. sedentaria*, were observed on the south shore of EB. Subadult males were seen in coastal lagoons near Gore Point.

KING EIDER. King Eiders nested abundantly but well-dispersed throughout the coastal strip surveyed. Although no females were seen on the unnamed island in the bay, one or a few would be easily missed among so many Common Eider females (one male King Eider was seen on the island). Sex ratio in a sample of arriving flocks was 45 males : 44 females. Prelaying feeding was observed only in freshwater ponds, not in meltwater channels in shore ice. Nests were on moss-lichen-*Dryas* ridges throughout the area and on rocky islands at the head of the bay. Females with broods moved from freshwater and brackish water areas (i.e. nesting ponds) toward saltwater lagoons as ducklings grew older. Nests and broods were roughly twice as numerous in 1979 as in 1980. An easterly migration of males along the south shore of EB was noted in both 1979 and 1980 (6 to 8 July), totalling 450 birds in 10 flocks.

WHIMBREL. Whimbrels were abundant through mid-August both years, usually in flocks of 5–30 but occasionally over 100 (especially in late July). Although more common within 500 m of the bay, they were also recorded further inland. We found no evidence of nesting.

RED KNOT. An adult with one flightless young was seen and photographed on the camp ridge on 22 and 27 July 1979. Courtship flights, chases and vocalizations were noted from 17 June to about 25 June 1980 in four separate locations. One "broody" female was encountered inland, about 6 km south of the EB shore.

SANDERLING. One nest and two broods were found and photographed in 1979 on ridges inland from the first terrace. Adults were seen almost daily in 1979 but were virtually absent in 1980.

BLACK GUILLEMOT. Nesting was recorded only on the unnamed island in EB. Two nests were found beneath boulders on a beach, and new eggs were added between 8 and 9 July 1980. A maximum of 30 birds was seen at one time on 10 July. None were seen along the south shore of EB.

Discussion

Our total of 41 species is comparable to totals from the other Southampton Island areas (cf. Parker and Ross 1973: 124). We recorded 35 species in 1979 and 39 in 1980. Those seen in one year only (Table 1) comprise species seen only once or very few times and only one certain nesting species (Black Guillemot, seen only on the unnamed island which was not visited in 1979). Observation of more species in 1980 is, in part, attributable to our being present for spring migration that year (e.g. Peregrine Falcon, Common Raven and Thayer's Gull may have been en route to nesting areas in nearby rocky cliffs of the northeast coast) (Sutton (1932), Smith (1966)). Poorer nesting in 1980 by some species (Snow Geese, King Eiders, Sanderlings) is attributable to a later melt.

The Red Knot young and Sanderling nest and young are the first definite evidence of breeding for these species on Southampton Island and confirm the

speculations of Sutton (1932) and Bray (1943). Ross' Geese have been reported nesting at Boas River, Southampton Island (Barry and Eisenhart 1958), but to our knowledge no previous evidence of nesting at East Bay exists. No species new to Southampton Island were recorded. The relative abundance of several species at EB differs from other Southampton Island sites studied. The colony of Common Eiders is one of the largest known concentrations in the Canadian arctic. EB had previously been regarded as only a minor breeding locality (Prach et al. 1981). Sutton (1932: 68–69) referred to known or possible nesting locations on Southampton Island but none with such large numbers; the current status of those nesting groups is unknown to us. EB may be a zone of contact between *S. m. borealis* and *S. m. sedentaria*. Egg size and examination of an injured female confirmed *S. m. borealis*; however, sight records suggested the presence of *S. m. sedentaria* also. The large number of Whimbrels was striking and their presence in flocks from late June onward indicated that EB may be a staging area for failed or non-breeders or fall migrants. Sutton (1932) believed they might nest in interior Southampton Island, but reported them uncommon except in fall. Parker and Ross (1973) and Bray (1943) also found them uncommon.

Additionally, the relative abundance of pairs of similar species were reversed from Parker and Ross (1973) whose records were for inland areas (Arctic and Red-throated loon, Lesser Golden and Black-bellied plover, Long-tailed and Parasitic jaeger; the latter species in each pair was more numerous at EB).

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Noncompetitive Coexistence between *Peromyscus* species and *Clethrionomys gapperi*

JERRY O. WOLFF[1] and RAYMOND D. DUESER[2]

[1]Department of Biology, University of Virginia, Charlottesville, Virginia 22901
[2]Department of Environmental Sciences, University of Virginia, Charlottesville, Virginia 22903

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A study was conducted to determine if the association of *Clethrionomys gapperi* with rock outcrops in an eastern deciduous forest was the result of habitat selection or competitive exclusion by *Peromyscus leucopus* and *P. maniculatus* which occurred in both rock and forest habitat. *Clethrionomys* did not move into forest habitat on a grid from which *Peromyscus* had been removed. Neither species exhibited aggressive behavior toward the other in paired behavioral trials. Food habits of *Peromyscus* and *Clethrionomys* differ substantially. We conclude that *Peromyscus* and *Clethrionomys* exhibit noncompetitive coexistence at this location, and that the association of *Clethrionomys* with rock outcrops results from habitat selection.

Key Words: *Clethrionomys gapperi*, competition, food habits, habitat selection, noncompetitive coexistence, *Peromyscus*, Virginia.

Clethrionomys gapperi (Southern Red-backed Vole) is sympatric with one or more *Peromyscus* species over much of its geographic range in eastern North America (Peterson 1966; Hall 1981). *Clethrionomys* occur in forest habitat with both *P. leucopus*, the White-footed Mouse (Beer 1961; Miller and Getz 1977a; Kirkland 1978) and *P. maniculatus*, the Deer Mouse (Fuller et al. 1969; Grant 1970; Miller and Getz 1977a,b; Kirkland 1978; Mihok 1979; Vickery 1981; Morris 1983). *Clethrionomys* has been observed to exhibit synchronous population fluctuations with both *P. leucopus* (Miller and Getz 1977a), and *P. maniculatus* (Fuller et al. 1969). The home ranges of *Clethrionomys* have been observed to overlap with those of both *P. leucopus* (Beer 1961) and *P. maniculatus* (Vickery 1981). Vickery (1981) found no significant discrimination between the summer microhabitats of co-occurring *Clethrionomys* and *P. maniculatus*. Behavioral studies of *Clethrionomys* have revealed no significant interspecific aggression with either *P. leucopus* (Getz 1969) or *P. maniculatus* (Grant 1970). Observations such as these led Grant (1972) to describe *Clethrionomys* — *P. leucopus* and *Clethrionomys* — *P. maniculatus* as pairs of rodent species which have largely coextensive ranges but which exhibit either no competitive interaction or infrequent and unpredictable interaction.

The ranges of *Clethrionomys gapperi, P. leucopus noveboracensis*, and *P. maniculatus nubiterrae* (Cloudland Deermouse) overlap extensively near the Mountain Lake Biological Station in southwestern Virginia. The *Peromyscus* species usually are more abundant than *Clethrionomys*, and they occupy a greater variety of sites, including the small (< 1 ha) rock outcrops scattered through the forest. *Clethrionomys* is most numerous on these rock outcrops and is seldom encountered away from outcrops. This patchy occurrence of *Clethrionomys* and the resultant "included range" of this species within that of *Peromyscus* raises the question of whether voles are excluded from the surrounding forest by competition with *Peromyscus* species or whether they actively select rock habitat. These circumstances provide an opportunity to test the claim (Grant 1972) that *Clethrionomys* — *P. leucopus* and *Clethrionomys* — *P. maniculatus* represent pairs of species which exhibit noncompetitive coexistence.

Study Area and Methods

Mountain Lake Biological Station is located at an elevation of 1150 m on Salt Pond Mountain, Giles Co., Virginia (37°22′N, 80°32′W). This area is in the Ridge and Valley Section of the Oak-Chestnut Region (Braun 1950; Stephenson 1982). The forest overstory is dominated by oak (*Quercus* spp.), Red Maple (*Acer rubrum*), and hickory (*Carya* spp.). The understory is composed primarily of Chestnut (*Castanea dentata*), Striped Maple (*Acer pensylvanicum*), Mountain Laurel (*Kalmia latifolia*), and azalea (*Rhododendron* spp.). The ground cover is composed of ferns, primarily *Osmunda* spp., and blueberry (*Vaccinium* spp.). Outcropppings of Silurian sandstone and shale ranging in size up to 1 ha are scattered throughout the forest. Woody and herbaceous vegetation is sparse on these outcrops, but mosses, lichens and fungi are abundant.

Four live-trapping grids ranging in size from 0.36 to

TABLE 1. Description of the study sites, size of rock outcrop, number of traps in each habitat, and trapping periods. In 1980 and 1982 Hedwig grid included additional trap stations in forest habitat.

Grid	Area of grid (ha)	Area of outcrop (ha)	Traps in forest (N)	Traps on outcrop (N)	Trapping period
Hedwig (1980)	1.28	0.32	96	32	8 July – 14 August 1980
Hedwig (1981)	0.56	0.28	28	28	18 July – 9 August 1981
Hedwig (1982)	1.28	0.32	96	32	22 June – 9 August 1982
Johns Creek (1981)	0.63	0.45	19	44	18 July – 9 August 1981
Grid 2 (1980)	1.00	0.27	73	27	13 March – 19 October 1980
Laurel (1980)	0.36	0.10	26	10	19 July – 14 August 1980

1.28 ha and 70 to 200 m apart were established to determine the distributions of *Clethrionomys* and *Peromyscus* with respect to habitat type (Table 1). Each grid included a rock outcrop and surrounding forest habitat. Trap stations located on the outcrop ranged from 25% to 70% of the total stations on a grid. All trap stations were at 10 m intervals. On each grid, traps were run for three to five consecutive days at 1 to 2 week intervals except for 1981 when trapping was conducted for four consecutive days at weekly intervals. One Sherman live trap (8 x 9 x 23 cm) baited with either peanut butter or solid shortening was set at each trap station. All traps were checked twice daily at 0800 and 1900 h. All animals were ear-tagged for permanent identification. Tag number, species, sex, weight, trap station and habitat type (rock or forest) were recorded for each capture. Laurel Grid was established in 1980 to test for a numerical response and/or habitat shift by *Clethrionomys* following the removal of *Peromyscus*. All *Peromyscus* were removed from Laurel Grid following an initial 5-d census period; colonization by mice and voles was then monitored for the following three weeks. *Peromyscus* were continuously removed as they recolonized the grid.

Interspecific aggression is one of the mechanisms by which *Peromyscus* might exclude *Clethrionomys* from forest habitat. To examine the behavioral relationship between the adults of these genera, 21 interspecific, intrasexual paired encounters were conducted in the field. Fifteen trials were conducted at trap stations where *Peromyscus* were captured and six at stations where *Clethrionomys* were captured. Because it was possible to run only a small number of trials, and in order to maximize the chance of observing any habitat-dependency in behavior, all 15 *Peromyscus* stations were in forest habitat and all six *Clethrionomys* stations were in rock habitat. Trials were conducted between 0800 and 1000 h during a regular trapping session in August 1980. Body weights of animals used in the trials ranged from 17 g to 25 g for *Peromyscus* and from 19 g to 31 g for *Clethrionomys*. All trials were conducted between adults of the same sex. Immature individuals and visibly pregnant females were excluded from the trials.

All trials were conducted in a clear, open-bottom plexiglass arena 32 cm in diameter and 48 cm high, following the procedures of Wolff et al. (1983). Each trial was conducted in the home range of one of the resident animals. Residents were those animals caught at three or more trap stations over at least a 2 week time period. One animal was placed on each side of a removable partition. The partition was removed after a 20 s acclimation period. The following behaviors were observed for the next five minutes: *Offensive approach* — orientation and movement of one animal toward its opponent which elicits either a defensive or retreat response in the latter; *Attack* — a sudden lunge toward an opponent, resulting in contact; *Chase* — following rapidly behind a retreating animal; *Retreat* — rapid escape after an attack or offensive approach by the opponent; *Avoidance* — avoidance of one individual in response to the presence or movement of the other; *Touching* — contact between any two parts of the body, usually the face or forepaws, which does not elicit a retreat or defensive response by the opponent; and *Defense* — rising on the hind legs and lashing out with forepaws in response to an offensive approach or attack by an opponent. The animal with the highest total number of attacks, offensive approaches, and chases was declared the winner of the trial. If neither animal exhibited aggression and if neither made an attempt to displace the other, the behavior and interaction were declared nonaggressive.

Results

Peromyscus leucopus and *P. maniculatus* did not differ in habitat utilization on these grids (R. D. Dueser and J. O. Wolff, *unpublished*), nor in agonistic behavior (Wolff et al. 1983). Therefore, these two species are considered together below. *Peromyscus* were more abundant than *Clethrionomys* on all grids except Hedwig 1982 (Table 2). This was true for both

TABLE 2. Number of individuals observed and the number of captures of each species in forest and rock outcrop habitat on each grid. "Residents" are those individuals which were captured ≥ 3 times over at least a 2 week interval. Numbers under capture locations are observed and (expected) based on percentage of traps in each habitat. χ^2 computed using Yates correction for continuity. df = 1.

	Individuals observed		Capture locations			
Grid/species	Residents	Other	Forest	Outcrop	χ^2	*P*
Hedwig (1980)						
Clethrionomys	10	16	9 (31)	33 (11)	56.93	0.001
Peromyscus	14	17	114 (97)	15 (32)	11.31	0.001
Hedwig (1981)						
Clethrionomys	18	5	30 (56)	82 (56)	23.22	0.001
Peromyscus	27	8	94 (89)	84 (89)	0.46	N.S.
Hedwig (1982)						
Clethrionomys	8	12	23 (44)	36 (15)	37.57	0.001
Peromyscus	8	6	39 (42)	17 (14)	0.59	N.S.
Johns Creek (1981)						
Clethrionomys	7	10	1 (25)	83 (59)	31.45	0.001
Peromyscus	29	25	87 (70)	146 (163)	5.56	0.01
Grid 2 (1980)						
Clethrionomys	6	23	16 (68)	77 (25)	145.09	0.0001
Peromyscus	21	85	260 (232)	58 (86)	12.05	0.001
Laurel (1980)[1]						
Clethrionomys	3	0	2 (6)	6 (2)	8.17	0.005
Peromyscus	15	0	47 (45)	16 (18)	0.18	N.S.

[1]Distribution of *Clethrionomys* and *Peromyscus* during initial five-day census.

resident individuals and for transients who were caught during only one trap period. Voles were caught more frequently than expected by chance in rocky habitat on every grid (Table 2). Mice were captured at random with respect to habitat on Hedwig in both 1981 and 1982 and on Laurel Grid, but they were captured more frequently than expected in forest habitat on Hedwig 1980, Johns Creek, and Grid 2.

Home ranges were mapped for the resident animals on each grid using the minimum-area method (Stickel 1954). The cumulative range of the vole population overlapped the range of the *Peromyscus* population by 81%, 65%, 94%, and 90% on Hedwig (1981), Hedwig (1982), Johns Creek, and Grid 2, respectively; *Peromyscus* range overlapped Southern Red-backed Vole range by 62%, 38%, 56%, and 33% on these same grids.

During a 5-d census period, 15 mice and three voles were marked on Laurel Grid. On the last two days of trapping, all 15 mice were removed. During the next three weeks, 12 new mice immigrated and were removed. No new voles were caught on the grid during this time, and the remaining three voles did not expand their use of trap stations. During this same time period five and eight voles had moved into the rock piles on Hedwig and Grid 2, respectively.

No significant differences were observed in agonistic behavior between voles and *Peromyscus* when trials were conducted in either rock or forest habitat or in male or female pairings. Consequently, all data were combined regardless of where the trial was conducted and whether it was between males or females (Table 3). Out of 21 paired dyadic encounters between voles and *Peromyscus*, only two resulted in a win/loss decision. Two female *Peromyscus* attacked voles 12 times, resulting in retreats or defensive postures by voles. No aggressive behaviors were displayed by voles. In the remaining 19 trials, the participants were tolerant of each other and no attempt was made to displace the opponent. Other than the 12 attacks by the two *Peromyscus* females, the most common behavior exhibited by both voles and mice was avoidance. On 13 occasions in four different trials, animals touched each other without eliciting an aggressive response.

Discussion

There are two spatial scales of interest here. On the scale of the forest, *Clethrionomys* were largely restricted to rock outcrops, whereas *Peromyscus* occurred in both rock and forest habitat. The species' ranges on this scale indicate clearly that voles do not prevent the occupation of rock habitat by mice. On the smaller scale of the rock outcrop within the forest,

TABLE 3. Mean (and SD) number of aggressive and submissive behaviors exhibited by *Clethrionomys gapperi* and *Peromyscus* spp. in 5-min encounters.

Species	N	Offensive Approach	Attacks	Chases	Retreats	Avoidance	Defense	Touches
Peromyscus	21	0.05 (0.22)	0.62 (2.20)*	0	0	0.33 (0.91)	0	0.52 (1.97)
Clethrionomys	21	0	0	0	0.35 (1.18)	0.35 (0.99)	0.35 (0.59)	0.15 (0.49)
Probability (t-test)		0.33	0.21	0.50	0.20	0.96	0.21	0.41

*Ten (77%) of the 12 attacks were performed by one female.

voles and mice exhibit pronounced habitat overlap. This overlap is evident from extensive interspecific overlap in home ranges. This joint occupancy of outcrops, but not forest, suggests either that mice do not prevent the occupation of forest habitat by voles or that such exclusion is dependent on conditions peculiar to the forest habitat. The failure of *Clethrionomys* to respond to the removal of *Peromyscus* either in the short-term, unreplicated experiment reported here or in a more powerful long-term, replicated experiment conducted by J. H. Porter (personal communication) argues for the former. The association of voles with rock outcrops thus seems to occur independently of the presence of mice in the surrounding forest. More generally, previous studies of *Clethrionomys* and *Peromyscus* spp. have reported similar interspecific overlap in home ranges (Beer 1961; Vickery 1981) and habitat use (Grant 1970; Vickery 1981; Morris 1983). These observations are consistent with the suggestion that *Clethrionomys* and *Peromyscus* generally coexist with little or no active competition (Grant 1972; Morris 1983).

This conclusion is further supported by the lack of interspecific aggression between voles and mice. Laboratory studies of interactions between Southern Red-backed Voles and *P. maniculatus* (Grant 1970) and red-backs and *P. leucopus* (Getz 1969) have been ambiguous, with both *Peromyscus* species and *Clethrionomys* winning a comparable number of trials and no clear-cut dominance being established. This is in marked contrast to behavioral interactions between congeners or closely related species which exhibit considerable ecological similarity (e.g. between *Microtus pennsylvanicus* (Meadow Vole) and *Clethrionomys gapperi*: Grant 1970; *Microtus montanus* (Montane Vole) and *M. pennsylvanicus*: Murie 1971; *M. montanus* and *M. longicaudus* (Long-tailed Vole): Colvin 1973; Randall 1978; *M. pennsylvanicus* and *M. ochrogaster* (Prairie Vole): Getz 1962; Miller 1969; and *Peromyscus leucopus* and *P. maniculatus*: Wolff et al. 1983). In these studies, interspecific aggression was evident and resulted in exclusion of a subordinate species or individual from a preferred habitat or territory. No such interactions occurred between voles and mice in our study.

There are two conspicuous differences in resource use between *Clethrionomys* and *Peromyscus* which may serve to reduce the probability of competition. First, *Clethrionomys* and *Peromyscus* differ in their use of arboreal habitat. Both *Peromyscus* species in this study make extensive use of trees for foraging and nesting (Nicholson 1941; Horner 1954; Getz and Ginzberg 1968; Wolff and Hurlbutt 1982; Harney 1983), whereas Southern Red-backed Voles remain on the ground (Getz and Ginzberg 1968; R. D. Dueser and J. Wolff, *unpublished*). Second, *Clethrionomys* and *Peromyscus* differ substantially in food habits. Food habits of *P. leucopus* and *P. maniculatus* at Mountain Lake (Wolff et al. 1985) were compared with those of *Clethrionomys* from West Virginia (Schloyer 1977) and Ontario (Martell 1981; Table 4).The *Peromyscus* species have similar diets composed mostly of arthropods, with berries and seeds being seasonally important (Berry 1984). The diet of *Clethrionomys*, in contrast, is dominated by lichens (or lichens and green plants) and fungi. Compositional differences of the diets of *Clethrionomys* and *Peromyscus* spp. are pronounced. When the diets of *Peromyscus* species are combined and averaged and compared with the diet of *Clethrionomys*, they show a similarity index (percent of overlap: Gauch 1973) of 18.0%. Southern Red-backed Voles and both species of *Peromyscus* are opportunistic foragers and may alter their diets seasonally (Whitaker 1962; Martell 1981; Martell and Macaulay 1981; West 1982; Berry 1984) or in different microhabitats (Schloyer 1976, 1977; Whitaker 1963, 1966; Martell and Macaulay 1981), but not to the extent that they overlap significantly.

The most parsimonious interpretation then, is that *Clethrionomys* is associated with rock outcrops in this forest because of active habitat selection (see also Morris 1983). This habitat selection is probably related to the particular moist subnivean conditions provided by rock outcrops. Throughout their range in

TABLE 4. Comparison of food habits of *Peromyscus* spp. from Mountain Lake and *Clethrionomys gapperi* from eastern North America. Table values are percent frequency of occurrence in the diet.

Food item	*P. leucopus*[1]	*P. maniculatus*[1]	*C. gapperi*[2]	*C. gapperi*[3]
Arthropods (and other animal material)	57.1	59.1	0.7	2.0
Green vegetation	9.8	8.6	5.6	75.9
Lichens	—	—	58.6	
Seeds	5.9	10.2	2.4	—
Berries	18.0	15.1	2.8	—
Fungi	4.9	4.3	30.6	21.9
Unknown	4.3	2.0	—	—

[1]Wolff et al. 1985 [3]Schloyer 1977
[2]Martell 1981

the eastern United States, Southern Red-backed Voles are confined to cool-moist situations (Stormer 1968; Miller and Getz 1972, 1973, 1977a,b; Kirkland and Griffin 1974), apparently as a result of their high moisture requirements and poor water economy (Getz 1968a,b,c). Preferred foods may also be more abundant in these microhabitats. *Peromyscus*, on the other hand, is apparently adapted to a wide range of environmental conditions and can exist in either moist rocky areas or in the drier upland habitats (Miller and Getz 1977b). *Peromyscus* also has a more varied diet. There appears to be a latitudinal effect on microhabitat distribution of *Clethrionomys*. In the southern part of their range where this study was conducted, Southern Red-backed Voles are restricted to rock outcrops or extremely moist areas along streams or bogs. In their more northern range, Southern Red-backed Voles occupy a wider range of forest conditions, but are still tied to a moisture regime. *Clethrionomys* evolved as a northern species (Hoffmann 1981) and may reach its physiological limits in the southern Appalachian Mountains.

Acknowledgments

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Ceratopsian Dinosaurs from the Frenchman Formation (Upper Cretaceous) of Saskatchewan

TIM T. TOKARYK

Saskatchewan Museum of Natural History, Wascana Park, Regina, Saskatchewan S4P 3V7

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Remains of ceratopsian dinosaurs have been known from the Frenchman Formation since the early 1900s. A summary of the published record of these remains and a discussion and probable identification of two *Triceratops* skulls and a *Torosaurus* frill, based on material in the Saskatchewan and Eastend museums, are an addition to our knowledge of these forms.

Key Words: *Triceratops, T. prorsus, Torosaurus*, Frenchman Formation, Upper Cretaceous, Saskatchewan.

The two youngest dinosaur faunas in Canada have come from the Red Deer River in Alberta (Upper Edmonton or Scollard Formation) and from southwestern Saskatchewan (Frenchman Formation). An index fossil for these beds is the ceratopsian dinosaur *Triceratops* (Sternberg 1924) because its remains are abundant and easily recognizable.

Triceratops has been reported from the Frenchman since 1924, but only a few ceratopsian specimens have been discussed or described at any length. The purpose of this paper is to review the published records and to discuss two *Triceratops* skulls and a *Torosaurus* frill.

Review of Ceratopsidae from Saskatchewan

The first faunal list of the Frenchman Formation was given by Charles M. Sternberg (1924). Several taxa were listed including *Triceratops prorsus*? Marsh. Russell (1930: 152–154) later listed essentially the same fauna.

Sternberg (1949: 43) described a new species of *Triceratops* (*T. albertensis*) from the upper Edmonton Formation of Alberta and also reviewed other specimens.

> "In the collections of the Geological Survey of Canada there are two nasal horncores that were collected from the Frenchman Formation of southern Saskatchewan. In size, form, and angle these suggest the nasal horncore of a large *Triceratops prorsus*. One specimen, G.S.C. No. 8598, was collected from Morgan Creek (east branch of Rocky Creek), Saskatchewan, and consists of the anterior part of the nasals and the horncore. From the anterior base of the horncore to the tip is 12 inches and from the anterior base back to the broken edges of the nasal bones is the same distance. Posteriorly the right and left nasals can be taken apart, and the suture dividing them is visible on the top of the horncore almost at the tip. The extreme was injured by exposure, but there is no evidence of a separate bone on or near the top. The other specimen, G.S.C. No. 8864, collected from the north side of the Frenchman River east of Eastend, Saskatchewan does not have as much of the nasal bones behind the horncore, but the tip is preserved. The two halves of this horncore are thoroughly fused, but the sutural union can be detected on the anterior face. These specimens show that in at least one species of *Triceratops* the nasal horncore was developed as outgrowths of the nasal bones, as in other Ceratopsidae."

Erickson (1966: 12) identified a large scapulocoracoid in the Eastend Museum, Eastend, Saskatchewan, as *T. prorsus*, based on its large size. This specimen (EM P14.1) is a plaster cast. The original is part of an incomplete skeleton in the Royal Ontario Museum (ROM No. 1434) collected by L. S. Russell in 1939 on the south side of the Frenchman River Valley, southeast of Eastend.

Russell (1967: 9), in a review of dinosaurs collected from western Canada, stated that 14 specimens of *Triceratops* and one "undetermined long-squamosalled ceratopsian" had been collected from the Frenchman.

All of the identified ceratopsian specimens collected in the Frenchman have been referred to *T. prorsus*. Tyson (1982: 1247), however, referred to a specimen in the Eastend Museum as "*Torosaurus*-like". The specimen is discussed below.

Few other Ceratopsian remains are known from Saskatchewan. While working in Upper Cretaceous marine deposits of southern Saskatchewan, Wann Langston Jr. recorded (1959 unpublished field notes on file in the Paleobiology Division, National Museum of Natural Sciences, Ottawa) that A. E. Swanston "located several ceratopsian bones consisting of the distal end of a tibia with attached astragalus and several caudal vertebrae. They rested on a small hill of slumped gray shale and had weathered from above, presumably from the shale, possible 250 feet above river level ... Evidently, the hind quarters of this animal were originally present. There is no question of its occurrence in the Bearpaw Formation." No identification of this specimen was

offered. This is not the only record of a terrestrial animal to have been collected from the marine deposits in Saskatchewan. Caldwell (1968: 76) briefly mentioned that a partial skeleton of a large hadrosaur had been collected from this same formation.

Systematic Palaeontology

Institute abbreviations: ANSP, Academy of Natural Sciences, Philadelphia; EM, Eastend Museum, Eastend, Saskatchewan; SMNH, Saskatchewan Museum of Natural History; YPM, Yale Peabody Museum.

ORDER Ornithischia Seeley 1888
SUBORDER Ceratopsia Marsh 1890
FAMILY Ceratopsidae Marsh 1888
GENUS Triceratops Marsh 1889

Triceratops cf. *T. prorsus*

The holotype of *Triceratops prorsus* is a nearly complete skull (YPM No. 1822) described by Marsh (1891). "The type skull is that of an aged individual, but one of small size; in fact, its overall length of but 5 feet 1 inch, makes it the smallest *Triceratops* species and specimen known" (Lull 1933: 117). A nearly complete skull (SMNH P1163.4) is herein referred to this species. Several other bones were collected from the same quarry but may not represent the same individual. This specimen was collected by the SMNH staff in June, 1967, in the Frenchman River Valley, south of Shaunavon, Saskatchewan. A second specimen (EM P15.1), consisting of a partial skull, is also referred to this species. It was collected by Charles F. Holmes, George Beane and H.S. "Corky" Jones in the summer of 1936, again in the Frenchman River Valley.

Discussion of SMNH P1163.4 (Figure 1 and Table 1)

The skull is well preserved. Its large size suggested an adult individual. The thick, non-fenestrate frill, two large anterior facing, supraorbital horncores identify this specimen as *Triceratops*. The rostral of the SMNH specimen and the holotype are similar in that their ventral margin projects downward at an angle of 45°, relative to the ventral margin of the maxillary. The suture between the premaxilla and rostral of the SMNH specimen suggests an older individual than the type because it is barely visible on the referred skull. The nasal horncore of the type differs in that it extends farther anteriorly than in the SMNH skull, where the nasal horncore extends dorsally. This is probably a result of individual variation. The narial opening is large in the SMNH specimen, forming an inverted triangle, as in the type. Though the specimen includes both maxillae, no teeth are preserved. The supraorbital horncores are more upright than in the type specimen. Both left and right supraorbital horncores are missing their apices, though they have been reconstructed to the presumed height and curvature. The area of the jugal, quadratojugal, quadrate and epijugal of the SMNH skull is not preserved on the left side. The frill is laterally compressed due to compaction following burial and on the right side the squamosal and parietal overlap to make the right side short compared with the left. Epoccipitals are present, though heavily fused.

Discussion of EM P15.1 (Figure 2 and Table 1)

This partial skull is larger than SMNH P1163.4. The suture between the rostral and premaxilla is well defined and open, suggesting that this may be a subadult individual. The upper portion of the narial

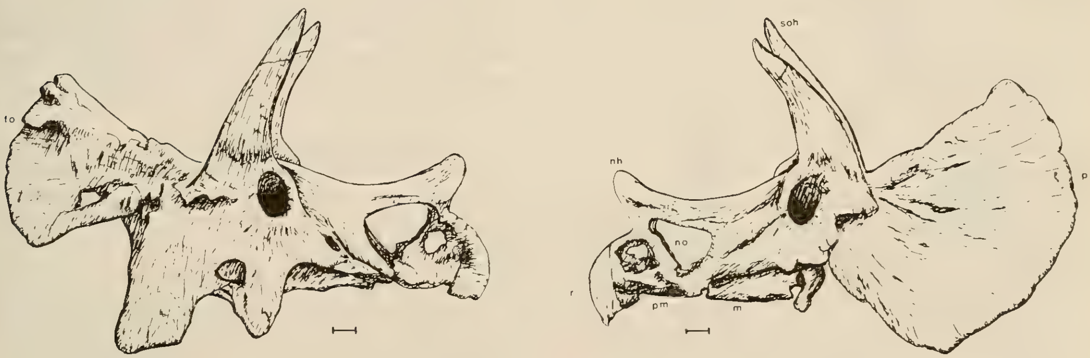

FIGURE 1. *Triceratops* cf. *T. prorsus*, SMNH P1163.4, left and right lateral view. Scale bar equals 100 mm. Abreviations: fo — fold between squamosal and parietal; m — maxilla; nh — nasal horncore; no — narial opening; p — parietal; pm — premaxilla; r — rostral; soh — supraorbital horncore.

TABLE 1. Measurements (in mm) of the Type *Triceratops prorsus* skull from Lull (1933), and the Referred Specimens. Measurements from the orbit in the referred specimens are made from the centre.

	EMP 15.1	YPM No. 1822	SMNH P1163.4
Greatest length of skull	—	1523	2100
Greatest width of frill	—	944	1020
Distance from orbit to the apex of supraorbital horncore	763	550	660[1]
Length of nasal horncore measured along lower side	346	210	315
Distance from apex of supraorbital horncore to apex of nasal horncore	610	650	850[1]
Greatest diameter of orbit	224	128	210
Least diameter of orbit	153	122	135
Distance from orbit to apex of rostral	1291	712	955
Distance from orbit to apex of nasal horncore	915	660	760

[1]Restored.

opening is similar to that in P1163.4 though it is not the same shape as in the type. The nasal horncore extends farther dorsally than in either YPM or SMNH specimens. The supraorbital horncores are also erect though not as upright as the nasal horncore. The frill of the specimen is not preserved nor are the jugals, quadratojugals, quadrates or epijugals. An incorrect reconstruction of this area was made by the original preparator. The holotype of *T. prorsus* and the referred SMNH skull have rugose antorbital ridges which are lacking in the EM specimen.

Comments

Both the SMNH and EM *Triceratops* skulls are similar to the type of *T. prorsus* and agree with descriptions of this species given by previous authors. The similar shape of the narial openings and orientation and shape of the nasal and supraorbital horncores in these specimens lead me to tentatively identify these skulls *Triceratops* cf. *T. prorsus*.

Steel (1969: 76) reported that "A fairly generalized central group in which no particular specializations are present seems to be represented by *T. albertensis, T. horridus, T. brevicornus* and *T. prorsus*;" however, at one time or another there were approximately 13 species of *Triceratops* from the Lance Formation of Wyoming, Montana and Colorado and its equivalents in Canada. Some workers (D. Tanke, personal communication, 1984) believe that this is an excessive number of species and that this number could possibly be reduced to two or three. Lehman (1982: 176) has even suggested that "all of the adequately known 'species' of *Triceratops* probably represent the varied individuals of a single species," based on sexual dimorphism.

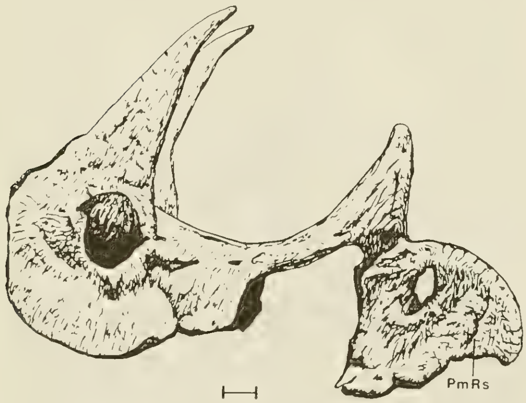

FIGURE 2. *Triceratops* cf. *T. prorsus*, EM P15.1. Right lateral view. Scale bar equals 100 mm. Abbreviations: PmRs — suture between Premaxilla and rostral.

Torosaurus sp. Marsh 1891

A nearly complete frill (EM P16.1) collected by Charles Morely is herein referred to *Torosaurus* sp. It was found in the Frenchman River Valley, Frenchman Formation.

Discussion of EM P16.1 (Figure 3 and Table 2)

The diagnosis of *Torosaurus* given by Colbert and Bump (1947: 103) describes the frill as an elongated fenestrated frill with a very long and blade-like squamosal. The parietal border of the squamosal is thickened, forming a distinct ridge at the juncture of the squamosal and parietal bar. These features are

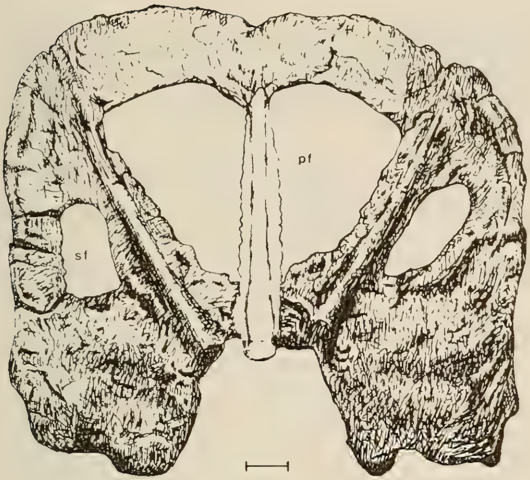

FIGURE 3. *Torosaurus* sp., EM P16.1, dorsal view. Scale bar equals 100 mm. Abbreviations: pf — parietal fenestrae; sf — squamosal fenestrae.

present in EM P16.1 and suggest that this specimen belongs to *Torosaurus*. The long parietal bar along the parietal/squamosal border, the large parietal fenestrae, the slightly cardoid parietal, blade-like squamosals, and the slight indentation of the posterior end of the parietal all agree with *Torosaurus*. This specimen is thus the first record of *Torosaurus* in Canada. Its previously known geographic distribution, as noted by Lawson (1976) and Lehman (1981), is Wyoming, South Dakota, Utah, New Mexico, and Texas.

EM P16.1 is fragmented and flattened. The parietal bar was not preserved and has been reconstructed. The specimen is broad and more quadrangular than any other known *Torosaurus* specimens, including *T. latus* and *T. utahensis*.

Though the parietal bar was reconstructed by its original preparator, the parietal fenestrae as preserved are considerably more oblong than *T. latus*, the only known species with an entire frill preserved. The circumferential border of the fenestrae are thin with no definite edge. The same can be said of the squamosal fenestrae, which are unusual. Lull (1933: 127) reported several occurrences, noting "squamosal bones pierced by large fenestrae," including *Arrhinoceratops brachyops, Pentaceratops fenestratus, Chasmosaurus brevirostris, Torosaurus latus* and *Triceratops* (= *Diceratops*) *hatcheri*.

Comments

The relatively great width of the frill in EM P16.1 and the oblong parietal fenestrae are unlike those in other known species of *Torosaurus*. The paired squamosal fenestrae are probably not taxonomically useful, be they either pathological or gerontic in origin. The closest affinities of EM P16.1 are with *T. latus* chiefly because it lacks epoccipitals and has proportionally larger squamosals than those known in *T. utahensis*. Vascular sulci, another characteristic of *T. latus* (Lawson 1976: 163), cannot be detected on this specimen due to its fragmented state.

Tyson (1981: 1246) has suggested that "isolated ceratopsian frill fragments from Lance equivalent or Horseshoe Canyon equivalent sediments showing thin parietals, minor undulations of the edges of the squamosals, circular or elliptical parietal fenestrae of moderate size should be classified as "Ceratopsidae, *incertae sedis*." Apart from *Torosaurus*, the only similar ceratopsian is *Arrhinoceratops brachyops* Parks. The larger parietal fenestrae, larger frill, and stouter squamosal bar all, however, suggest that EM P16.1 pertains to *Torosaurus*.

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TABLE 2. Measurements (in mm) of the EM *Torosaurus* sp. and of a referred and type specimens of *Torosaurus latus* from Colbert and Bump (1947).

	ANSP No. 15192	YPM No. 1830	EM P16.1
Greatest diameter of left squamosal fenestrae	—	—	330
Greatest diameter of right squamosal fenestrae	—	—	290
Greatest breadth of frill	1240	1700	1620
Anterior-posterior length of parietal fenestrae	340	—	660

of Canada) for supplying me with information which eventually led to the exact locality of the EM *Triceratops* specimen; Loris S. Russell (Royal Ontario Museum) for providing me with information on the scapulocorocoid in the Eastend Museum; all the people associated with the Eastend Museum for their helpful cooperation and last but not least Shelley Keiser for retyping my own typing mistakes.

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Oil Pipeline Crossing Sites Utilized in Winter by Moose, *Alces alces,* and Caribou, *Rangifer tarandus,* in Southcentral Alaska

STERLING H. EIDE, STERLING D. MILLER, and MARK A. CHIHULY

Alaska Department of Fish and Game, 333 Raspberry Road, Anchorage, Alaska 99502

Eide, Sterling H., Sterling D. Miller, and Mark A. Chihuly. 1986. Oil pipeline crossing sites utilized in winter by Moose, *Alces alces,* and Caribou, *Rangifer tarandus*, in southcentral Alaska. Canadian Field-Naturalist 100(2): 197-207.

Crossing sites selected by Moose (*Alces alces*) and Barren-ground Caribou (*Rangifer tarandus granti*) were studied along a 145 km segment of the Trans-Alaska oil pipeline in southcentral Alaska during the first winter of pipeline operation. Physical characteristics of the pipe were recorded at locations where Moose and Caribou tracks were found in the snow on the pipeline pad. The characteristics of pipe design at these encounters were compared with the availability of these characteristics based on construction drawings. No consistent pattern of selection by Moose was found for different vertical clearance heights of elevated pipe, for buried vs. elevated pipe, or for sites where the pipe was specially elevated or buried for short distances to facilitate crossings. Apparently, Moose were not influenced in their selection of pipeline crossing sites by pipeline characteristics. They may have been influenced prior to reaching the pipeline pad, or may not yet have established preferred crossing sites. Caribou tended to select for elevated pipeline heights over 8 feet [2.4 m] and against those less than 7 feet [2.1 m]. Caribou showed strong selection for long buried sections of the pipeline that were intentionally located in areas where Caribou migrations traditionally crossed the pipeline corridor. Caribou showed no selection for the short, specially-designed, crossing sites.

Key Words: Moose, *Alces alces*, Caribou, *Rangifer tarandus granti,* oil pipeline, movements, Alaska.

The construction of the Trans-Alaska Oil Pipeline through important Moose (*Alces alces*) and Caribou (*Rangifer tarandus granti*) habitats in Alaska caused concern that the pipeline might obstruct movements of these species. Therefore, a condition of construction required that free passage and movement of big game animals be provided throughout the life of the project. To achieve this goal, a number of recommendations were made by state, federal and private-sector biologists. These included elevating some short segments to heights thought sufficient to permit free passage under the pipe. These specially-designed, elevated segments ("elevated DBGCs") exceeded 10 feet [3.0 m] in clearance from the bottom of the pipe to the top of the pipeline pad throughout the length of the segment (generally 60 feet [18.3 m]). Long sections were buried, some equipped with refrigerator coils to avoid melting the permafrost. These long buried sections averaged 1.1 km in length in the section of pipe studied. Short buried segments, known as "sagbend crossings," were scattered throughout long sections of elevated pipe; the buried portion of these sagbends was typically less than 60 feet [18.3 m]. Elevated DBGCs, sagbends, and some of the long buried sections were located in areas known to be regularly used by big game species or thought to have a high probability of utilization based on traditional movements or habitat characteristics.

Our study was designed to evaluate the use of the crossing structures specifically designed to permit free passage of Moose and Caribou across the pipeline corridor and to evaluate where animals chose to cross the pipeline at sites that were not specially designed to facilitate crossings. Evaluation was based on observations of the pipeline characteristics at locations where Moose and Caribou encountered or crossed the pipeline as indicated by tracks on the pipeline pad.

Study Area and Methods

The Trans-Alaska Pipeline is routed through the Copper River Basin from the crest of the Alaska Range near Summit Lake to the crest of the Chugach Range near Thompson Pass. Our observations were confined to a 145 km segment of the Trans-Alaska Pipeline corridor from Meiers Lake to Squirrel Creek. The pipeline route in this segment generally follows the drainages of the Gulkana and Copper rivers (Figure 1).

In this area, the pipeline intersects important Moose migratory routes where many animals which spend the summer and fall seasons in the Alphabet Hills and Chugach Mountains migrate eastward across the pipeline and adjacent Richardson Highway to their winter ranges in the lowlands near the Copper River. The timing of these movements varies from year to year depending largely on snow depths. Early winter migrations occur from November to early February and westward spring migrations from mid-April to mid-June (VanBallenberghe 1977; W. B. Ballard, personal communication).

Within the study area, the pipeline also crosses the migratory route of the Nelchina Caribou herd. Since

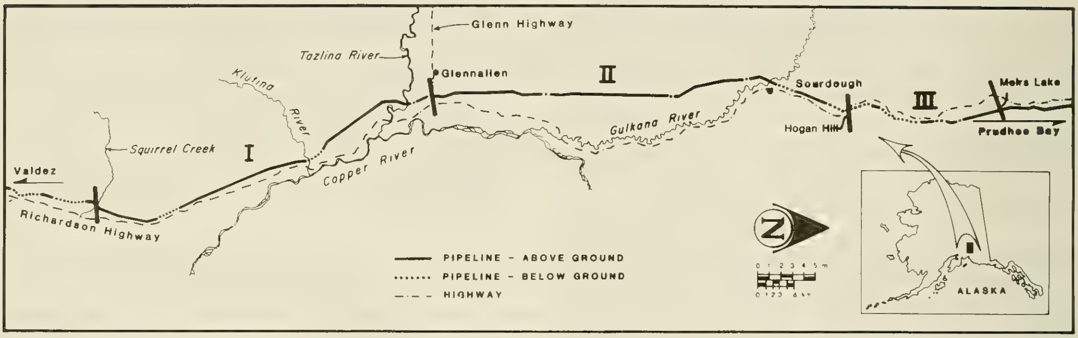

FIGURE 1. The three sections of the Trans-Alaska oil pipeline studied in winter 1977–78.

the early 1960s, this herd has characteristically moved westward to its calving grounds in the Talkeetna Mountains between March and May. The herd returns to wintering areas, largely along the Gakona, Chistochina and upper Copper rivers, between October and January (Skoog 1968; Hemming 1971; Pitcher, Kenneth W. 1982. Susitna Hydroelectric Project, Phase II Progress Report, Big Game Studies, Volume IV. — Caribou. Alaska Department of Fish and Game. 43 pp.). In most years, these movements require crossing the Richardson Highway and since 1977, the pipeline as well.

A Moose or Caribou crossing above-ground segments of the pipeline does so through a rectangular "window". For the animal, this window is defined laterally by the vertical support members (VSMs) on either end of that pipeline segment, ventrally by the top of the pipeline pad, and dorsally by the bottom of the pipe (Figure 2). This rectangular window is 60 feet [18.3 m] wide and of variable height. A single value was calculated to represent the vertical clearance (height) for each such window in the study area. This calculated value was the average of the clearances heights at the VSMs on each end of each 60-foot long segment. These VSM heights (distance from the top of the pipeline pad to the bottom of the pipe) were obtained from a list published by the Alyeska Pipeline Service Company (Listing of As-redesigned VSM Construction Section 1 and 2: 20 April 1977).

The frequency distribution of calculcated vertical clearances was compared with the frequency distribution of measured vertical clearances (top of pad to bottom of pipe) where Moose or Caribou tracks encountered elevated segments of the pipe. For these analyses, the data on calculated and measured vertical clearances were grouped in 1 foot [0.3 m] intervals. However, because of their rarity, clearances of less than 5 feet [1.5 m] were combined as well as clearances greater than 13 feet [4.0 m].

Similar analyses were conducted comparing the proportion of the pipeline which was buried to that which was constructed above-ground. The amount of buried pipe was obtained from Construction Record Drawings (ER 1454 As-Built update, April 1980); these data were converted to 60 foot [18.3 m] segments, so that they could be compared to the data for elevated pipe.

Comparisons were also made of the measured vertical clearance at each crossing with the calculated clearance at that crossing in order to test the validity of using calculated clearances as a measure of the actual clearance under the pipe.

The dominant vegetation along the pipeline in the study area is a mixture of Black Spruce (*Picea mariana*), White Spruce (*Picea glauca*), Aspen (*Populus tremuloides*), Balsam Poplar (*Populus balsamifera*), Paper Birch (*Betula papyrifera*), Shrub Birch (*B. glanulosa*), and willow (*Salix* spp.), interspersed with sedge meadows, shallow lakes and riparian habitats. Understories of *Vaccinium* spp., *Ledum* spp., lichens, and mosses are prevalent. The terrain in the study area is gently sloping except where watercourses have cut steep banks through the rolling hills. More detailed descriptions of this area were presented by Skoog (1968).

In terms of maximum snow depths and total snow accumulation, the snowfall data collected by the United States Soil Conservation Service at Gulkana, Alaska, indicated that the winter of 1977-78 was in the lower third of winters from 1960-1982. Crossing sites utilized by Moose and Caribou during winters with greater snow accumulation may differ from those reported in this study.

These data were analyzed using three geographically different groupings of the data. The first level of analysis included all observations along the entire 145 km length of the pipeline in the study area. The second level subdivided this 145 km length into three

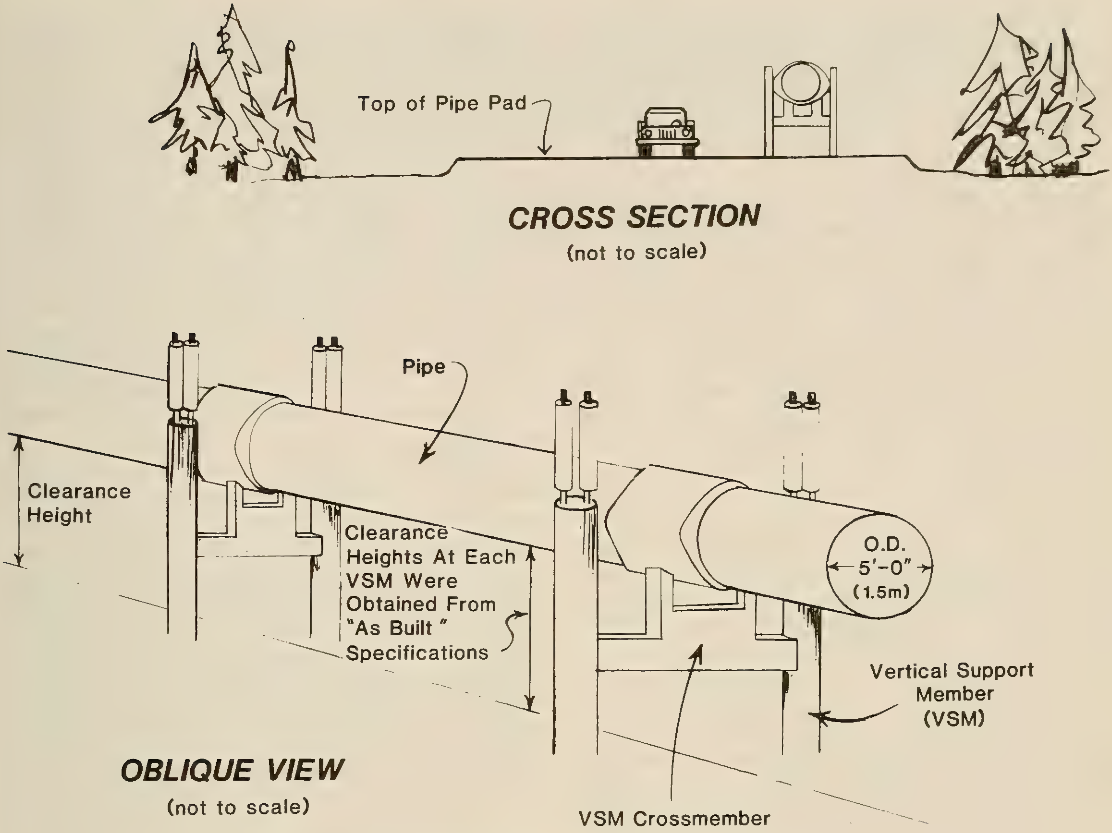

FIGURE 2. Pipeline measurements and construction features.

sections, each capable of being inspected by truck or snow machine in a single day's travel (Figure 1). Each section was characterized by differences in habitat type, Moose and Caribou usage, and pipeline characteristics. These characteristics are outlined below.

Each of these three sections was long (36-60 km) in comparison to Moose home range sizes or to the distance Caribou were considered likely to move to find an acceptable crossing site. Correspondingly, the whole frequency distribution of calculated vertical clearance heights in a section of pipe was not necessarily available to any of the animals inhabiting that section. Therefore, a third level of analysis was conducted using eight geographically distinct subsections of elevated pipe, four subsections for Moose and four for Caribou. For each species, these subsections were selected, after the field data were collected, to include those lengths of pipe where crossings were most concentrated. These subsections, correspondingly, were likely in the best habitat types at least for Moose. These eight subsections varied in length from 0.7 to 1.6 km. No comparisons of use of buried vs. aboveground construction modes was conducted on these subsections as no long buried sections were present. Statistical analyses of the subsection data were conducted in the same manner as for longer sections of the pipe, except that smaller sample sizes frequently made it necessary to combine vertical clearance height categories. The subsections used for these analyses cumulatively included only 18.7 per cent of the total number of Moose encounters with elevated pipe and 24.7 per cent of the total Caribou encounters.

Section I was a 50.4 km segment from the Glenn Highway near Glennallen south to Squirrel Creek, the southernmost portion studied. Eighty-eight per cent of the pipeline in this section was elevated including 28 specially-designed, short, elevated game crossings (elevated DBGCs). Section I also contained one sagbend, one long buried section (2.6 km), a buried river crossing at the Klutina River, an elevated crossing at the Tazlina River, and a buried crossing of the Glenn highway. The Nelchina Caribou herd did not cross

this section during the study period. This section of the pipeline was searched for tracks on 16 and 27 November; 6, 14, 22 and 28 December; 4, 10, 13, 22 and 30 January; 20-21 and 30-31 March; and 14 April. Section I contained none of the short subsections that were identified on the basis of where concentrated crossings were found.

Section II was a 60.4 km segment from the buried Glenn Highway crossing near Glennallen to the buried Richardson Highway crossing at Hogan Hill. Here the terrain is virtually flat and soil types and permafrost characteristics required that the pipeline be constructed above ground except for five sagbend crossings and two long refrigerated buried sections (2.9 and 4.2 km). Eighty-eight per cent of the pipeline in this segment was elevated and there were 29 elevated DBGCs. Based on numbers of Moose crossings (533), this section was in the best Moose habitat. This section of the pipeline was searched for tracks on 27 October; 6, 17, 28, and 30 November; 9, 13, 21 and 27 December; 5, 16, 25 and 31 January; 22 and 28 March; and 6, 19-20, and 30 April. Additional observations were also made on 25-28 April. Moose subsections B, C, and D and Caribou subsections E and F were in Section II.

Section III was a 37.3 km segment from the Richardson Highway crossing at Hogan Hill to Meiers Lake, the northernmost portion studied. In this section, elevations are higher and the terrain is more uneven. Snow depths in this section were greater than in the other two sections. Because of better soil drainage characteristics, the pipeline was buried for 38 per cent of its extent in this section; these included seven long buried segments (0.9, 0.9, 2.0, 1.3, 1.4, 0.3, and 0.7 miles [1.5, 1.5, 3.2, 2.1, 2.3, 0.5 and 1.1 km]) and five sagbends. There were 24 elevated DBGCs.

This section of the pipeline was searched for tracks on 30 October; 9, 18, 25 and 31 November; 10, 12, 18 and 29-30 December; 11, 16, 20 and 26-27 January; 1 and 22 February; and 11 April. Moose subsection A and Caribou subsections G and H were in Section III.

The surveys were conducted by truck or snow machine and, occasionally, on foot. Surveys were conducted when fresh snow permitted the observation of tracks on the pipeline pad. For each set of Moose or Caribou tracks encountered on the pipeline pad, the following data were collected:

1. Distance from the bottom of the pipe to the top of the pad (vertical clearance) (Figure 2) at all encounters of above-ground sections of the pipe.
2. Location of the encounter according to pipeline construction nomenclature (Vertical Support Member — VSM — number).
3. Whether the tracks indicated a crossing of, or a deflection from, the pipeline (each crossing or deflection is termed an "encounter" in this paper).
4. Whether the encounter occurred at a buried section of the pipe or at a sagbend or elevated DBGC.
5. Direction of travel.

These data were sorted by computer utilizing SPSS (Nie et al. 1975).

Chi-square tests were performed to determine if the observed pipeline characteristics (segment height, or buried vs. elevated construction modes) at crossing sites differed from the calculated proportion of these characteristics available. We determined which cells of the Chi-square test contributed to rejection of the null hypothesis using the normal approximation to the binomial distribution to calculate adjusted residuals (z scores) (Everitt 1977). The critical value of the normal distribution was adjusted for simultaneous inferences.

For Moose, tests of crossing site selection were conducted on the total 145 km segment of the pipeline as well as on each of the three sections. For Caribou, tests were conducted only in Sections II and III, individually and combined, as no Caribou crossed Section I. Analyses by section were done to identify any differences between sections in the selection of pipeline characteristics where animals crossed; if the same selectivity patterns did not occur in each section, the "selectivity" observed could have been related to some attribute other than the pipeline characteristics measured.

Measurements and analyses of pipe characteristics were done using the U.S. system to reflect the system of measurements used in constructing the pipeline; metric equivalents are provided in brackets. Metric units are used where they do not refer to construction features of the pipeline.

Results

Pipeline Characteristics

The frequency distribution of calculated vertical clearance heights of the pipeline segments in our study area is presented in Table 1. The mean calculated vertical clearance height for the elevated segments of the pipeline was 7.4 feet [2.3 m]. Based on the calculated heights, 7.3 per cent of elevated pipeline segments had vertical clearances ≥ 10 feet [3.1 m].

Thirty-six percent of the specially-designed, short, elevated big game crossing sites (DBGCs) had calculated vertical clearances less than 10 feet [3.1 m]. Some of these were enlarged to the 10-foot specifications by the Alyeska Pipeline Service Company subsequent to our study. The average calculated vertical clearance at the elevated DBGCs was 10.3 feet (6.5 - 14.8 feet) [3.1 m (2.0 - 4.5 m)]. The average distance between DBGCs or between these and the nearest buried section was 1.14 km (range = 0.07-7.9 km).

TABLE 1. Characteristics of the Trans-Alaska Pipeline in the study area.

Calculated* Vertical Clearance Height in feet [metres]	Number of 60-foot [18.3 m] Pipeline Segments							
	Section I		Section II		Section III		Total	
	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent
Buried	319	11.6	393	11.9	775	38.0	1 487	18.4
1 - 4.9 [1.5]	75	2.7	80	2.4	14	0.7	169	2.1
5 - 5.9 [1.8]	461	16.8	411	12.4	71	3.5	943	11.7
6 - 6.9 [2.1]	789	28.7	782	23.7	213	10.4	1 784	22.0
7 - 7.9 [2.4]	522	19.0	779	23.6	361	17.7	1 662	20.5
8 - 8.9 [2.7]	263	9.6	494	15.0	265	13.0	1 022	12.6
9 - 9.9 [3.0]	155	5.6	192	5.8	195	9.6	542	6.7
10 - 10.9 [3.3]	71	2.6	88	2.7	93	4.6	252	3.1
11 - 11.9 [3.6]	37	1.3	38	1.2	19	0.9	94	1.2
12 - 12.9 [3.9]	25	0.9	27	0.8	10	0.5	62	0.8
13+ [4.0+]	35	1.3	18	0.5	24	1.2	77	1.0
Total	2 752	100.1	3 302	100.0	2 040	100.1	8 094	100.1

*Calculated as the mean of the VSMs on each end of the segment.

Calculated vertical clearance was compared with the measured clearance height where crossings occurred. For Moose and Caribou crossings, 82 and 75 per cent, respectively, of measured vertical clearances at crossings were within ± 1 foot of calculated values. For both species, 96 per cent were within ± 2 feet. These comparisons indicate that it was reasonable to use the As-built specifications to approximate the availability of different vertical clearance heights under the pipeline.

Moose Encounters

1. *Temporal Distribution of Encounters and Direction of Travel.* In January, significantly more eastbound Moose tracks were found on the pipeline pad than westbound tracks ($P < 0.05$) [Table 2]. Only in April were more westbound than eastbound tracks observed and this difference was not significant ($P \pm 0.10$) [Table 2]. These observations suggest that many of the crossings recorded in January were made by Moose during the early winter eastward migrations described by VanBallenberghe (1977) and Ballard (personal communication). The crossings recorded in April may have represented the start of the returning movement of these same Moose. During the other months the numbers of eastbound and westbound tracks were statistically equivalent, and most of the Moose crossings recorded probably represented regular movements within an individual's home range.

2. *Elevated Pipe.* The frequency distribution of measured pipe clearances where Moose crossed (Table 3) was compared with the frequency distribution of calculated vertical clearance heights available (Table 1). Significant deviations from expected values were observed for the entire length of the pipeline as well as

TABLE 2. Number of Moose track encounters with the Trans-Alaska oil pipeline by month and direction of travel during winter 1977–78.

Month	Eastbound tracks		Westbound tracks		χ^2*
	No.	Per cent	No.	Per cent	
October	13	68.4	6	31.6	2.6
November	32	58.2	23	41.8	1.5
December	181	51.3	172	48.7	0.2
January	278	55.8	220	44.2	6.8**
February	65	58.0	47	42.0	2.9**
March	62	51.7	58	48.3	0.03
April	67	44.1	85	55.9	2.1
Totals	698	53.3	611	46.7	5.8**

*H_0: No. Eastbound = No. Westbound.
**Reject H_0 ($P \leq 0.05$).

TABLE 3. Measured vertical clearances where Moose encountered the Trans-Alaska Pipeline.

Measured Vertical Clearance Height in feet [m]	Number of Crossings* (Number of Deflections**)			
	Section I	Section II	Section III	Total
Buried	40	21	61	122
1 – 4.9 [1.5]	4	3 (6)	1 (1)	8 (7)
5 – 5.9 [1.8]	40	106 (2)	26 (2)	172 (4)
6 – 6.9 [2.1]	74 (2)	153 (2)	69 (4)	296 (8)
7 – 7.9 [2.4]	75 (1)	121 (9)	70 (3)	266 (13)
8 – 8.9 [2.7]	41	46 (2)	89 (2)	176 (4)
9 – 9.9 [3.0]	31	45	47 (4)	123 (4)
10 – 10.9 [3.3]	6	27	37 (2)	70 (2)
11 – 11.9 [3.6]	1	8	5	14
12 – 12.9 [3.9]	0	0	0	0
13+ [4.0+]	3	3	5	11
Total	315 (3)	533 (21)	410 (18)	1258 (42)

*A crossing is where a set of Moose tracks crossed the pipeline pad and the pipe.
**A deflection is where a set of tracks was found on the pipeline pad that did not cross the pipe.

for each of the three segments considered separately ($P < 0.005$). Significant deviations were also observed for three of the four subsections of pipe ($P < 0.05$) (Table 4). These analyses suggested that Moose were not crossing through windows of different vertical clearance heights in proportion to their occurrence.

Adjusted residuals (z scores) for these data are presented in Tables 4 and 5. Although it appeared that Moose selected against clearance heights < 5 feet, there was otherwise no clear pattern between the three long sections of the pipe in the vertical clearances where Moose crossed relative to what was available (Table 5). Positive selection for vertical clearances of 7-7.9 feet [2.1-2.4 m) in subsection C and for > 7 feet [2.1 m] in subsection B was found in the analysis of the short subsections; no significant negative selection based on vertical clearance height was found in the analysis by subsection ($P > 0.05$) [Table 4]. This suggests that vertical clearance under the pipe was not the most significant criterion Moose used in selecting a location to cross elevated sections of the pipe except, perhaps, for very low sections of elevated pipe.

This absence of similar patterns among different sections and subsections suggests that the significant results reported above for individual sections and subsections may be spurious. If the degree of vertical clearance were the principal determinant of where Moose crossed the pipeline, the significant negative selection for clearances of 8-8.9 feet in Section II, for example, would not be balanced by positive selection for this clearance range in Sections I and III (Table 5).

Encounters where a Moose failed to cross the pipe-

TABLE 4. Adjusted residuals (z scores) for crossings of elevated pipe by Moose comparing observed numbers of crossings with expected values. A negative sign indicates that the observed value was less than the expected value.

Calculated Vertical Clearance Height (feet) [m]	Section I	Section II	Section III	Total
1 – 4.9 [1.5]	–1.6	–3.0*	—	–4.0*
5 – 5.9 [1.8]	–1.9	4.3*	0.8[b]	0.8
6 – 6.9 [2.1]	–2.0	1.5	1.5	–0.7
7 – 7.9 [2.4]	2.4	–1.6	–3.5*	–1.4
8 – 8.9 [2.7]	2.2	–4.8*	2.1	0.0
9 – 9.9 [3.0]	3.4*	2.0	–1.0	3.2*
10 – 10.9 [3.3]	–0.7	3.0*	2.3	4.1*
11 – 11.9 [3.6]	–2.2[a]	–1.0[a]	–1.2[a]	0.6
12 – 12.9 [3.9]	—	—	—	–3.3*
13+ [4.0+]	—	—	—	–0.6

[a]Data for windows >11 feet combined.
[b]Data for windows < 6 feet combined.
*Significant, $P < 0.05$, $z \geq +2.8, \leq -2.8$.

TABLE 5. Comparisons of the measured vertical clearances where Moose crossed elevated portions of Trans-Alaska Pipeline with the clearances available in each of four short subsections of pipe selected on the basis of concentrated numbers of crossings.

Calculated Vertical Clearance Height	Measured Vertical Clearance at Crossing											
	SUBSECTION A			SUBSECTION B			SUBSECTION C			SUBSECTION D		
(feet) [m]	No. Used (%)	No. Present (%)	Adjusted Residual***	No. Used (%)	No. Present (%)	Adjusted Residual***	No. Used (%)	No. Present (%)	Adjusted Residual***	No. Used (%)	No. Present (%)	Adjusted Residual***
< 6 [1.8]	6 (8.6)	10 (11.8)	-0.8	14 (18.7)	15 (28.3)	-1.9	—	—	—	14 (35.9)	15 (22.4)	+2.0
6–6.9 [2.1]	10 (14.3)	15 (17.6)	-0.8	21 (28.0)	22 (41.5)	-2.4	16** (47.1)	21** (53.8)	-0.8	13 (33.3)	23 (34.3)	-0.1
7–7.9 [2.4]	8 (11.4)	16 (18.8)	-1.6	40* (53.3)	16* (30.2)	+4.4	15 (44.1)	7 (17.9)	+4.0	6 (15.4)	9 (13.4)	+0.4
8–8.9 [2.7]	23 (32.9)	17 (20.0)	+2.7	—		—	3* (8.8)	11* (28.2)	-2.5	6* (15.4)	20* (29.9)	2.0
9–9.9 [3.0]	12 (17.1)	16 (18.8)	-0.4	—		—	—				—	—
10+ [3.0]	11 (15.7)	11 (12.9)	+0.7		—			—	—	—	—	—
TOTALS	70 (100)	85 (100)		75 (100)	53 (100)		34 (100)	39 (100)		39 (100)	67 (100)	
χ^2	9.4			19.1			17.8			6.1		
d.f.	5			2			2			3		
P	0.094			$\leqslant 0.005$			$\leqslant 0.005$			0.107		
Length of subsection (km)	1.0		0.7			1.6	1.2					

*Combined with values in subsequent cell(s).
**Combined with values in previous cell.
***Critical value for adjusted residual (P = 0.05) = > +3.11, <–3.11.

line within one pipeline segment of initial contact with the pipeline pad were classified as deflections. Forty-two deflections (3.2 per cent of Moose encounters with the pipeline) were recorded, all for pipeline windows < 11 feet [3.4 m] in vertical clearance (Table 3). No deflections were observed at buried sections of the pipeline. For 84 per cent of the deflections, the Moose apparently did not cross the pipeline at that time, while the remaining Moose crossed after paralleling the pipeline for two or more pipeline segments. In one case, a cow and calf were separated by a long section of pipe where the pipe clearance was below 5 feet [1.5 m] for several VSMs. Both Moose eventually crossed the pipeline, but these crossings occurred approximately 274 m apart.

Sixty-five percent of the 60 foot-long elevated pipeline segments utilized by Moose to cross the pipeline were crossed by a single set of tracks. Only 1 per cent of the segments that were crossed by Moose during this study period were crossed by five or more sets of tracks. The maximum number of tracks crossing a single segment of above-ground pipe was eight, and this occurred at an elevated DBGC where the measured clearance at the crossing was over 10 feet [3.1 m].

The lowest measured vertical clearance where a Moose crossed elevated segments of pipe was 4.1 feet [1.3 m]. Only 10 Moose crossings were recorded where measured vertical clearances were < 5.0 feet [1.5 m].

3. *Elevated vs. Buried Pipe.* In Sections II and III and for all three sections combined, the number of Moose crossings at buried segments was significantly lower ($P < 0.01$) than expected (based on the proportions of the pipe that were elevated and buried). No differences were found for pipe Section I ($P > 0.50$) where the lowest number of Moose crossings occurred.

4. *Specially-designed, Short, Elevated Big Game Crossing Sites (DBGC).* Of 81 elevated DBGCs in the three pipeline sections, 13 (16 per cent) were utilized by Moose. At least one Moose crossed 754 (12 per cent) of the 6526 remaining elevated segments. These data indicate no selection by Moose for the elevated DBGCs (χ^2 = 1.6, 1 d.f., $P > 0.1$).

Caribou Encounters

1. *Temporal Distribution of Encounters and Direction of Travel.* Most (70.3 per cent) of the Caribou encounters with the pipeline recorded during this study were of Caribou moving eastward during the fall migration (Table 6). The bulk of the Caribou moving west in the spring apparently crossed the pipeline in late April or March when snow conditions were inadequate to record their tracks (Table 6). There was a significant disparity in the proportion of tracks mov-

TABLE 6. Number of Caribou track encounters with the Trans-Alaska oil pipeline by month and direction of travel during winter 1977–78.

Month	Eastbound tracks No.	Eastbound tracks Per cent	Westbound tracks No.	Westbound tracks Per cent	χ^{2*}
October	403	84.8	72	15.2	231**
November	3086	97.9	66	2.1	2893**
December	449	52.6	405	47.4	2.0
January	275	87.3	40	12.7	175**
February	170	98.3	3	1.7	combined with March
March	1	6.3	15	93.8	124**
April	48	3.6	1271	96.4	1134**
Totals	4432	70.3	1872	29.7	

*H_0: No. Eastbound = No. Westbound.
**Reject H_0 ($P < 0.05$).

ing in one direction for each month of this study except December (Table 6); this suggests that most of the Caribou encounters recorded were migratory animals.

2. *Elevated Pipe.* In Sections II and III and in three of four subsections, the frequency distribution of measured vertical clearances at Caribou crossing sites varied from expected values based on the distribution of calculated vertical clearances (Tables 7 and 8). Differences were significant for Sections II and III both individually and combined ($P < 0.005$) and for three of four subsections ($P < 0.005$).

In Section II, Caribou showed negative selection for low vertical clearances < 7 feet [2.1 m] and positive selection for clearances of 7-9 feet [2.1-2.7 m] (Table 9). In Section III, Caribou also showed negative selection for lower vertical clearances (< 8 feet [2.4 m]) and positive selection for vertical clearances of over 10 feet [3.1 m] (Table 9). The pattern in the analysis by section indicated that Caribou selected against vertical clearances less than 7 feet [2.1 m]. The pattern for positive selection was less clear, although there appeared to be a tendency to select for clearances greater than 8 feet [2.4 m].

Analyses by short subsections of pipe revealed a pattern similar to the analyses by longer sections. In the three subsections where significant deviations from expected values were found ($P < 0.005$), Caribou showed negative selection for the lowest vertical clearance categories occurring in that subsection and generally positive selection for the higher vertical clearance categories (Table 8).

Deflections were recorded for 2.7 per cent of the

TABLE 7. Measured vertical clearances where Caribou encountered the Trans-Alaska Pipeline.

Measured Vertical Clearance Height in feet [m]	Number of Crossings* (Number of Deflections**) Section I	Section II	Section III	Total
Buried	—	1412	2550 (2)	3962 (2)
1 – 4.9 [1.5]	—	35	4	39
5 – 5.9 [1.8]	—	23 (3)	19 (3)	42 (6)
6 – 6.9 [2.1]	—	249 (7)	66 (29)	315 (36)
7 – 7.9 [2.4]	—	556 (19)	115	671 (19)
8 – 8.9 [2.7]	—	547 (6)	129 (2)	676 (8)
9 – 9.9 [3.0]	—	100	54 (48)	154 (48)
10 – 10.9 [3.3]	—	44	111 (24)	155 (24)
11 – 11.9 [3.6]	—	22 (6)	33 (24)	55 (30)
12 – 12.9 [3.9]	—	15	34	49
13+ [4.0+]	—	3	0	3
Totals	—	3006 (41)	3115 (132)	6121 (173)

*A crossing is where a set of Caribou tracks crossed the pipeline pad and the pipe.
**A deflection is where a set of tracks was found on the pipeline pad that did not cross the pipe.

TABLE 8. Comparisons of the measured vertical clearances where Caribou crossed elevated portions of Trans-Alaska Pipeline with the clearances available in each of four short subsections of pipe selected on the basis of concentrated numbers of crossing.

Calculated Vertical Clearance height	Measured Vertical Clearance at Crossing											
	SUBSECTION A			SUBSECTION B			SUBSECTION C			SUBSECTION D		
(feet) [m]	No. Used (%)	No. Present (%)	Adjusted Residual**	No. Used (%)	No. Present (%)	Adjusted Residual**	No. Used (%)	No. Present (%)	Adjusted Residual**	No. Used (%)	No. Present (%)	Adjusted Residual**
< 7 [2.1]	58 (42.0)	55 (73.3)	−8.3	15 (6.7)	10 (11.5)	−2.3	18 (14.0)	12 (16.4)	−0.8	17 (20.2)	11 (23.9)	−0.8
7–7.9 [2.4]	80* (58.0)	20* (26.7)	+8.3	50 (22.2)	63 (72.4)	−16.9	21 (16.3)	27 (37.0)	−4.9	24 (28.6)	11 (23.9)	+1.0
8–8.9 [2.7]	—	—	—	135 (60.0)	11 (12.6)	+21.4	70 (54.3)	14 (19.2)	+10.1	43* (51.2)	24* (52.2)	−0.2
9+ [2.7+]	—	—	—	25 (11.1)	3 (3.4)	+6.3	20 (15.5)	20 (27.4)	−3.0	—	—	—
TOTALS	138 (100)	75 (100)		225 (100)	87 (100)		129 (100)	73 (100)		84 (100)	46 (100)	
X^2	69			519			105			1.3		
d.f.	1			3			3			2		
P	< 0.005			< 0.005			< 0.005			0.52		
Length of subsection (km)	1.4			1.6			1.3			0.1		

*Combined with values in subsequent cell(s).
**Critical value for adjusted residual ($P = 0.05$) = > +3.11, < −3.11.

Caribou that encountered the pipeline (Table 7). Ninety-nine per cent of such deflections occurred at elevated sections of pipe (Table 7).

Deflections were observed for all vertical clearance height categories except those less than 5 feet and higher than 12 feet (Table 7), probably because of infrequent occurrence of these categories (Table 1).

In 30 instances (1.4 per cent of the total crossings of elevated pipe), Caribou crossed elevated sections of the pipe under a VSM rather than between VSMs. Animals crossing under a pair of VSMs had about half the vertical clearance height present under the adjacent pipe because of the cross members on the VSMs (Figure 2). The lowest vertical clearance where a Caribou crossing was recorded (3.2 feet [1.0 m]) was under such a VSM cross member. Thirteen Caribou crossings were recorded at measured vertical clearances < 4.0 feet [1.2 m]. All of these were under a VSM cross member.

Caribou crossings were observed at 255 elevated pipeline segments in Section II (7.7 per cent of elevated sections present), 140 segments in Section III (11.1 per cent), and 8.7 per cent of the elevated segments in both sections combined. Unlike Moose, the number of pipeline segments crossed by a single Caribou was relatively small — 28.1 per cent of the crossed segments. Five or more sets of tracks were observed at 33.7 per cent of the crossed segments.

3. *Elevated vs. Buried Pipe.* Selection by Caribou for buried sections of the pipeline was highly significant for Section II, Section III, and for the two sections combined ($P < 0.005$). In Sections II and III, respectively, the number of crossings at buried sections were 4 and 2.2 times greater than the expected values. These differences would have been even more marked if the lengths of pipe that were buried primarily for geotechnical or engineering reasons rather than to facilitate Caribou crossings had been excluded from the analyses.

These results do not necessarily indicate that Caribou actively searched for buried sections, however, as the buried sections were not randomly distributed along the pipe. Except for the buried highway and river crossings, buried pipe was located where Caribou traditionally crossed the pipeline corridor. Only two deflections of Caribou from the pipeline were observed at buried sections (1.2 per cent of total deflections) [Table 7].

4. *Caribou use of Specially-designed, Short, Elevated Crossing Sites (DBGCs).* Caribou crossings were recorded at 4 (7.5 per cent of the elevated DBGCs (N = 10 crossings) in Sections II and III. This percentage is lower than the proportion of all elevated segments that were used by at least one Caribou (9.5

TABLE 9. Adjusted residuals (z scores) for crossings of elevated pipe by Caribou comparing observed numbers of crossings with expected values. A negative sign indicates that the observed value was less than the expected value.

Calculated Vertical Clearance Height in feet [m]	Section II	Section III	Total
1 – 4.9 [1.5]	–1.4	–0.8	–1.4
5 – 5.9 [1.8]	–14.5*	–2.4	–14.0*
6 – 6.9 [2.1]	–10.2*	–3.3*	–10.1*
7 7.9 [2.4]	7.3*	–4.3*	3.9*
8 – 8.9 [2.7]	18.4*	1.3	15.8*
9 – 9.9 [3.0]	–0.5	–3.9*	–3.4*
10 – 10.9 [3.3]	–0.6	11.1*	6.5*
11 – 11.9 [3.6]	0.2	8.5*	4.7*
12 + [3.7+]	–1.4	5.0*	1.8

*Significant, $P < 0.05$, $z \geqq +2.8, \leqq -2.8$.

per cent) and indicates lack of selection by Caribou for the elevated DBGCs. Thirty Caribou were deflected at two elevated DBGCs. Both of these had vertical clearances of over 10 feet.

Ten sagbends were located in pipe Sections II and III. Caribou crossings were recorded at two of these (N = 23 crossings). Nineteen Caribou crossed under an elevated section which was adjacent to a sagbend (17 Caribou also crossed over that sagbend). One Caribou deflected at a sagbend.

Discussion

Studies in the arctic portion of the pipeline route indicated that Caribou cows with calves tended to avoid the pipeline corridor consisting of the pipeline and associated human activities along the pipeline (Cameron et al. 1979; Smith and Cameron 1983). Corresponding studies of Caribou movements in relation to the pipeline in the more timbered southern portion of the pipeline route, where this study was conducted, have not been published. We examined only the physical characteristics of the pipeline at sites where Caribou and Moose trails were found on the pipeline pad.

Demonstration of selectivity for or against certain pipeline characteristics is complicated by their nonrandom distribution. Buried segments, for example, were intentionally located in areas of historic Caribou movements. Correspondingly, the observed selection by Caribou for crossing buried pipe instead of aboveground sections may indicate continued use of traditional movement corridors rather than active selection for buried sections. At a minimum, however, our data indicate the sections of the pipeline that were buried to facilitate Caribou crossings were buried in the correct places.

The techniques employed in this study did not permit an analysis of pipeline-influenced behavior distant from the pipeline pad. Observations from fixed-wing aircraft during the course of this study indicate, however, that deflections sometimes occur some distance from the pipeline pad. On 24 October 1977, we observed a deflection of from 300 to 1000 Caribou tracks moving eastward. These Caribou deflected about 30 m from the pipeline, paralleled the pipeline for 1–2 miles and then turned away from the pipeline without crossing.

The distribution of Caribou crossings indicates that Caribou tended to avoid low segments of elevated pipe (less than 7 feet [2.1 m]). No consistent pattern of selection was found for Moose crossings.

Our data provide no evidence that Moose or Caribou crossings were facilitated by the specially-designed, short, big-game crossing sites, consisting of either high elevated sections (DBGCs) or sagbends. We suspect that Caribou, at least, might select for the sagbend crossings if these were more frequent in occurrence and were longer in extent. Subsequent studies may show selection for elevated DBGCs as they may become significant facilitators of Moose and Caribou crossings only after these animals learn where they are.

In most years (> 50 per cent), 90–95 per cent of the Nelchina Caribou herd crosses the Richardson Highway and the adjacent pipeline corridor during its eastward migration in the fall and again during its westward migration in the spring (K. Pitcher, personal communication). Since construction of the Trans-Alaska pipeline, this pattern has not changed (K. Pitcher, personal communication) and the herd had increased from approximately 14 000 in fall 1977 to approximately 25 000 in fall 1983 (Alaska Department of Fish and Game, unpublished data). These data indicate that this Caribou herd has increased in numbers since pipeline construction regardless of any impediments to Caribou movements that might have resulted from the presence of the pipeline across their migratory route. By these criteria then, the efforts

made to assure free passage of Caribou across the pipeline appear to have been adequate.

Similarly, Moose populations appear unaffected by the pipeline. Aerial counts of the sex and age composition of Moose populations have been conducted for 30 years in the Alphabet Hills population. This population includes individuals that migrate across the pipeline (VanBallenberghe 1977; W. B. Ballard, personal communication). Similar counts have been conducted in the Upper Gakona River area within 5 km of the pipeline corridor. These data indicate that the Alphabet Hills Moose population is currently larger, and at least as productive, as it was prior to pipeline construction and the upper Gakona River Moose population is at least as large as it was prior to pipeline construction (Alaska Department of Fish and Game, unpublished data and Robert Tobey, personal communication). The Alaska Department of Fish and Game biologist in charge of this area does not believe that the pipeline has so far had a measurable impact on the numbers or productivity of Moose in the populations adjacent to the pipeline (Robert Tobey, personal communication).

Our data indicate that Moose selected against buried segments relative to above-ground segments. However, these data may only reflect the fact that the long, buried sections were situated to facilitate Caribou crossings. Our data suggest that a Moose sufficiently motivated to get on the pipeline pad would usually cross regardless of the physical characteristics of the pipeline at that location. The clumped pattern of Moose crossings strongly indicated that the pipeline intersected different habitats of varying Moose densities. Analyses of selection for crossing sites based on vertical clearance characteristics within short areas of presumably good Moose habitats revealed the same lack of pattern as found in the analyses of longer sections of pipe.

Under the conditions that have existed since construction of the pipeline in our study area, our results indicate that the efforts made to permit passage of Moose and Caribou across the pipeline did permit such passage. There are additional mechanisms and conditions, however, by which crossing could be inhibited or blocked that were not investigated in this study. The most significant of these would likely be a severe winter with deep snow.

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Observations of Intraspecific Killing by Brown Bears, *Ursus arctos*

FREDERICK C. DEAN, LAURA M. DARLING, and ALISON G. LIERHAUS

Wildlife Program, University of Alaska-Fairbanks, Fairbanks, Alaska 99775-1780

Dean, Frederick C., Laura M. Darling, and Alison G. Lierhaus. 1986. Observations of intraspecific killing by Brown Bears, *Ursus arctos*. Canadian Field-Naturalist 100(2): 208-211.

Two cases of intraspecific killing by Brown Bears (*Ursus arctos*) were observed in Denali National Park, Alaska. An adult male attacked a family, partially paralyzing a female yearling and killing the adult female. The other yearling survived at least 10 weeks as an orphan. The second instance resulted in the death of a yearling and cannibalism by an adult male.

Key Words: Brown Bear, *Ursus arctos*, Alaska, mortality, intraspecific killing, infanticide, orphan, cannibalism.

Popular and scientific accounts of cannibalism by bears are frequent. However, in most instances, the associated information is insufficient to rule out scavenging which is common behavior among bears. Intraspecific killing has been reported or intimated for both Black Bears (*Ursus americanus*) and Brown Bears (*Ursus arctos*), generally in the absence of direct observations. A few examples, dealing with Brown Bears, follow. Troyer and Hensel (1962) discussed two cases of cub mortality definitely caused by large bears, one of which was identified as male and the other presumed to be male. Egbert and Stokes (1976) and Murie (1981) reported behavior of females with young that suggested fear of bears which the observers identified as large males; Murie also described an instance of a yearling being chased unsuccessfully by a presumed adult male. Herrero (1978), Bunnell and Tait (1981), McCullough (1981), and Stringham (1983) reviewed limited selections from the literature on intraspecific killing in bears and the possible role of adult males in population regulation through infanticide. Few specifics are available due to the scarcity of direct observations. A description of one such observation follows.

We witnessed an instance of intraspecific killing on 20 May 1984 in Denali National Park, Alaska, about 1.5 km SE of the E end of the highway bridge across the Toklat River (63 30′ N, 150 04′ W). We watched from a section of the park road that traverses the hillside; at the lookout the road was about 15 m above the terrain below. Between the base of the slope and the active gravel bar of the glacial river there was an area of stabilized, vegetated bar just over 2 km long (NW-SE), for most of its length 100-150 m wide, and about 1.5 m above the bare gravel (see Figure 1). The vegetation was dominated by shrubs, scattered low willows (*Salix* spp.) and abundant Soapberry (*Shepherdia canadensis*); Mountain Avens (*Dryas octopetala*) and Peavine (*Hedysarum alpinum*) were common in the herb layer. Leaves on the shrubs had not yet emerged, and visibility was essentially unhampered by vegetation.

An adult female Brown Bear with two yearlings (second-summer young) was on the vegetated bar about 25-30 m from the base of the slope when we arrived at the viewpoint at 1207 h Alaska Daylight Time. Subsequent comparison of the animals' morphology and color characteristics with Dean's 1983 notes indicated a high probability that the family was one that had frequented the same area the previous summer. The adult female and the lighter-colored yearling were digging roots of *Hedysarum alpinum* fairly steadily; the other yearling was digging less actively than its sibling. All three were within a few meters of each other. Cloud cover was less than 10%; the direct sun was hot with an air temperature of 15-20° C; a light breeze was blowing from the SE. We watched the undisturbed family for nearly 20 min, which afforded time for good observation and numerous photographs.

At some time between 1225 h and 1230 h Dean saw a fairly large, light-brown adult male bear (see below) moving SE parallel to the road and about 10 m out onto the flat from the base of the slope. Another observer subsequently reported seeing this animal a few minutes earlier 1 km NW of our lookout. When we first saw the male he was definitely aware of the other bears and was altering his course toward the family group. He walked upwind toward the other bears until within about 20 m of them. The family was closely spaced at this time with the adult female nearest the male. A lot happened within a few seconds; the action is illustrated in Figure 1. Beginning about 1 sec before we were sure that the female had seen the intruder, both adults were heard growling and huffing. The family members each ran in a different direction when the male rushed them. The darker yearling headed SW a few meters and then NW; we lost track of it almost immediately. The mother went a few meters E, and the light-colored yearling bolted S

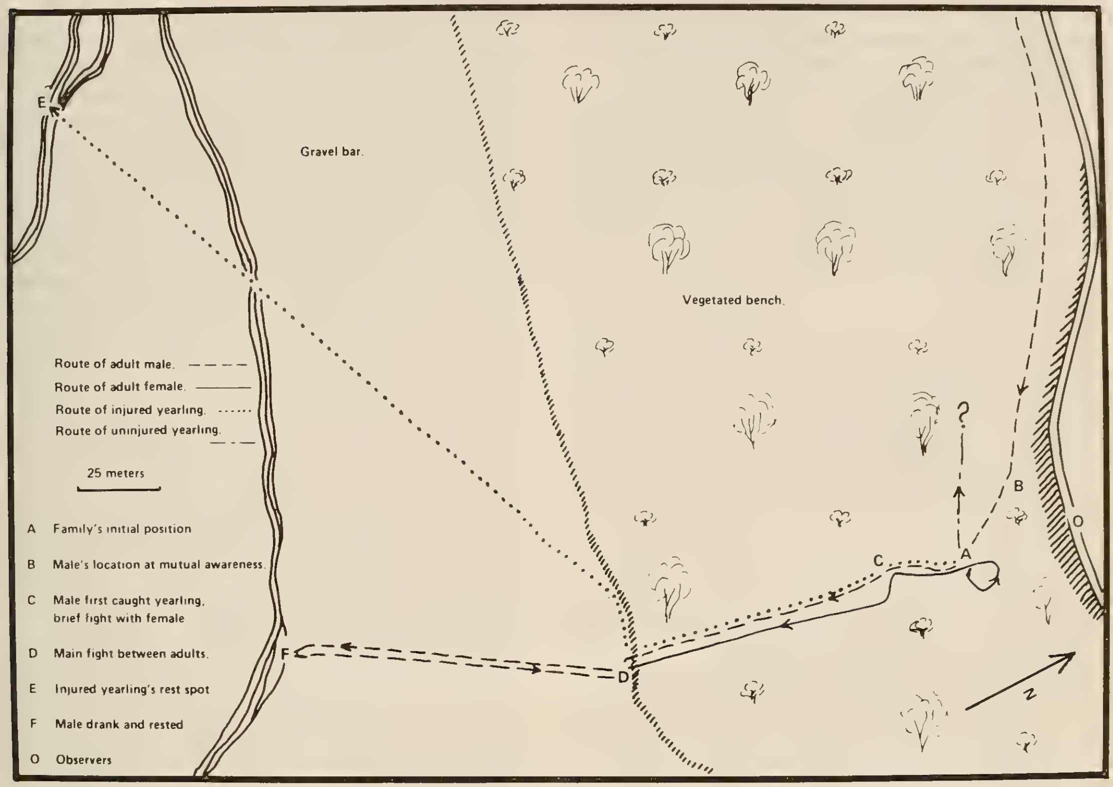

FIGURE 1. Map of area of first observations showing positions of bears (A-F) and observer (O) and routes taken by bears involved.

toward the gravel bar, not far out of line with the male's rush. The male swung a few steps left toward the female, then right, following the light-colored yearling. The mother stopped, turned full circle left, and followed the chase. The male caught up with the yearling after the latter had covered about 25 m; he knocked the young animal over with a paw swipe just before the adult female rushed in to attack him. After fending off the sow, he chased after the yearling again. There was low growling as the three disappeared over the low bank at the outer edge of the vegetated bar. The adults soon stood on their hind legs, with their upper torsos in view, grappling and biting. Less than 30 seconds elapsed between the male's initial rush and the joining of the two adults at point "D" (Figure 1). The light-colored yearling came back in sight about 5 m to the NW of the fighting adults. The yearling's hindquarters appeared to be paralyzed because it was dragging its back end and hind legs, but we saw no blood on it. The injured yearling initially headed parallel to the edge of the gravel bar, but gradually turned W out across the open bar.

Meanwhile the fight between the two adults raged on. Several times the female broke out from under the male, rose to her hind legs, and bit at his head, neck, and shoulders while the animals stood. Most of the time, however, the male kept the female pinned out of sight just over the drop at the edge of the vegetated bar. Subsequent examination of photographs showed that he was at least 33% larger. (H. Reynolds, Alaska Department of Fish and Game, kindly reviewed his data for Brown Bears handled just E of Denali National Park. The girth-weight relationship appears quite variable in these data, but the sow's 128 cm girth suggests a live weight between 120 and 140 kg.) The male clearly had to work hard to subdue her, apparently chewing in the neck region and shaking her head and neck. The female made no noticeable attempt to flee during the brief periods that she was not pinned. While there had been some growling there was no very loud roaring from either adult. The male had killed or immobilized the sow after 15–20 min. By that time he had large patches of blood on his neck and shoulders, probably mostly hers. We were unable

to confirm any substantial lacerations on him; several loosened hair tufts were evident. The male then moved 50–100 m W to the first channel with flowing water; he sat in the water, appeared tired, and also drank.

In the meantime the injured yearling had dragged itself a total of about 200 m from the location of the fight, eventually swinging slightly SW and crossing several shallow stream channels. The darker yearling was still out of sight. Although the male had walked in the general direction of the injured yearling, he showed no awareness of, or renewed interest in, the younger animal.

After about 5 min, the male returned to the female's carcass and began ripping at it with his mouth. He appeared to be eating from the carcass, which was below the lip of the bank, for nearly 1 h. During the last 15 min of this period he was interrupted by Black-billed Magpies (*Pica pica*), common in the immediate area, which hopped about within a few meters. After feeding, and possibly in response to the birds, the male began to scrape sand and gravel over the body of the female. He fed and scraped alternately for about 1 h and then lay down on top of the pile to rest. By 1718 h the male bear was doing little but lie on top of the dirt pile covering the body of the female.

The injured yearling had continued to move to a point about 300 m from the carcass and about 250 m from the road. It stayed upright until 1528 h when it lay on its side.

The next day Dean returned to the lookout above the carcass at 1153 h and found the male still lying on the carcass but awake. By 1238 h the male had turned onto his side in a manner which exposed his genitals, allowing confirmation of the sex. The injured yearling was lying a few meters from its position of the previous evening, occasionally raising its head in response to the infrequent noise of passing vehicles. The arrival of a helicopter being used on other work permitted a very quick search of the unforested areas within 2 km of the kill site; the uninjured yearling was not found. Dean left the area about 1430 h, returning at 1711 h; the male was still lying on the cache. Another observer reported that the injured yearling had moved about 30 m to the edge of a stream channel between 1645 h and 1711 h.

Park maintenance personnel reported that the male was gone from the cache most of the day on 22 May; it was seen travelling E from the W side of the Toklat River late in the day, but was not observed near the carcass at that time. The same observers saw the uninjured yearling, seemingly confused, within 100 m of the carcass of its mother late on 22 May.

On the morning of 23 May we first checked the area at 0930 h and watched continuously from 0950–1050 h. The only bear seen at that time was the injured yearling, still in the same place it had been in at 1820 h the previous evening. During the afternoon of 25 May, the injured yearling moved NE to the road. It was still paralyzed in the hind quarters and moved with a sort of hopping procedure, balancing on the front legs which were placed under its abdomen. It was shot by NPS personnel and subsequently was determined to be a female. Its weight was estimated between 18–20 kg.

Also on the afternoon of 25 May a park technician sighted the uninjured yearling in the location where he and Dean had first seen the family in 1983, about 3.5 km ENE of the kill site. Dean and Darling spotted the orphan 0.5 km S of this last sighting point at 1648 h 28 May; the animal was digging, presumably for *Hedysarum alpinum* roots, despite a moderate snowstorm. The orphan was seen every day or so in the general area for about 2 weeks and then less frequently until mid-August. A number of the sightings were at or very close to the carcass of its mother. On 7 June Darling watched (from 7 km) a lone Wolf (*Canis lupus*) interact with the orphan at the carcass site; the wolf darted in and away several times during the 10 min it stayed in the area.

On 9 June Darling was able to inspect the carcass which had, by this time, been uncovered. The orphan had been about 25 m from the carcass when she arrived at the lookout. There were surprisingly few openings in the skin and flesh, considering both the male's appearance of having eaten a good deal immediately after the fight and the subsequent scavenging activity. One teat appeared as if it might have been sucked recently. Dean inspected the carcass on 19 June. Most of the hair was gone from the exposed (right) side, and two holes were noted, one in the mid-upper part of the abdomen and one in the rear, lower part of the abdomen. Both were 70-80 mm diameter and of indeterminate origin and timing. On the left side there was a hole just posterior to the head of the humerus; it was about 150 mm in diameter and 100 mm deep. This wound had been made at the time of the fight or by eating immediately afterward; there was a large amount of blood matted in the surrounding hair. No other signs of serious wounds were noted. It is possible that some of the male's actions which we interpreted as eating were, in fact, a final effort to kill the near-dead female. The limited amount of exposed flesh seen on the carcass was clearly less than we had anticipated as a result of our observations.

Dean worked in Denali National Park studying bears for many years without witnessing an incident such as was described above. Consequently, it was with real surprise that he received word on 7 June 1985 that a yearling bear had just been killed by an adult

about 1.6 km further up the road. He proceeded quickly to the scene, arriving approximately 30 min after the kill took place. Beginning about 1205 h, a shuttle bus driver and several passengers witnessed most of the chase of a small, adult female and one yearling; a serious but brief fight (about 5 sec) between the aggressor male and the adult female; and the initial stages of the male's feeding on the carcass of the yearling. The driver provided Dean with a detailed account (P. Shearer, personal communication). The evidence suggests that the dark-colored yearling was killed just before the fight. Dean and I. Mysterud saw an area of about 30 cm diameter in the north roadside ditch that was covered with wet blood. The fight took place on the road about 250 m NW of point "B" in Figure 1. Dean watched the adult male feeding on the yearling from about 30 m for nearly 45 min. There was no question in this case; the carcass was being consumed steadily. Dean saw the scrotum, confirming the sex of the aggressor, as the bear carried the remains a few meters farther from the road in response to the arrival of several vehicles. The male covered the remains of the yearling at 1406 h and rested on or beside the spot. Other observers reported that the male fed again on the carcass, continuing off and on until at least 2100 h.

It was interesting that this second incident happened within a few hundred meters of the 1984 case. It is possible, on the basis of general appearance, that the male was the same individual in both cases; without unique marks there was no way of being certain. The evidence in Shearer's report suggests little if any influence on the situation (except perhaps the duration of the fight) from his bus. On 8 June 1985 Dean observed the male leaving the immediate vicinity and spent several hours watching a small female with one light-colored yearling. The family worked down from a high slope about mid-day, dug roots on the river bar, and then took a difficult route up a steep rock and talus face to a high bench. The entire time that the mother and young were on the valley bottom they were exceedingly nervous. The yearling that was killed was most probably taken from a family of two yearlings that had been seen several times in the area during the weeks preceding the incident. The surviving yearling had apparently split from the family prior to Shearer's observation of the chase, perhaps taking refuge in the tall willows covering most of the area.

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Lesser Snow Geese, *Anser c. caerulescens*, Nesting in the Western Canadian Arctic in 1981

RICHARD H. KERBES

Canadian Wildlife Service, 115 Perimeter Road, Saskatoon, Saskatchewan S7N 0X4

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A total of 103 800 pairs of nesting Lesser Snow Geese (*Anser caerulescens caerulescens*) in the western Canadian Arctic was estimated from aerial photographs obtained in June 1981, an increase of 22% over the total estimated by similar methods in 1976. In both years most birds were in the Egg River colony on Banks Island with small proportions in the Anderson River (4% in 1981, 2% in 1976) and Kendall Island (1% in both years) colonies. The density of nesting birds increased greatly between years, especially at Egg River, where it was over four times greater in 1981 than it was in 1976, owing to less snow-free area at the beginning of the 1981 season. This population can be monitored more accurately on its breeding grounds than on its wintering grounds.

Key Words: Lesser Snow Goose, *Anser caerulescens caerulescens*, nesting, inventory, Northwest Territories.

Lesser Snow Geese, *Anser caerulescens caerulescens*, are among the most numerous waterfowl of North America, but their nesting is concentrated in a few large colonies. Aerial photography of those colonies can be used to document the numbers of birds and their nesting patterns (Kerbes 1975, 1983).

The western Canadian Arctic population of Lesser Snow Geese nests in a large colony at Egg River, Banks Island, and in small colonies at Anderson River and Kendall Island in northwest Mackenzie District, Northwest Territories. I estimated the numbers of nesting birds in those colonies from counts on large-format aerial photographs obtained in 1976, and compared those results to earlier visual estimates (Kerbes 1983). Here, I report results of a photographic inventory of those colonies conducted in 1981.

Methods

As in 1976, aerial photographs were obtained from a small twin-engined aircraft flying at 760 m above ground level with a Wild RC10 camera using a 152-mm lens and Kodak 2402 Plus X film. Details of film analysis procedures were as described by Kerbes (1983). All photographs were made on 13 June 1981. Anderson River and Kendall Island colonies were completely photographed, and total counts of nesting birds were subsequently made from the photographs. The large colony near Egg River was systematically sampled by a series of parallel lines of photographs crossing the colony from east to west. The estimate of total number of nesting birds in the colony was extrapolated from the sample of photographic counts. Birds distributed in pairs or singles on the ground were classified as nesting, and those in flight or in flocks as non-breeders (Kerbes 1983).

Results and Discussion

Of the total 103 800 pairs in 1981, 95% were at the Egg River colony, with 4% at Anderson River and 1% at Kendall Island (Table 1). Kerbes (1983) suggested that the population of Lesser Snow Geese nesting in the western Canadian Arctic increased over the period 1952 to 1976. With the 1981 total some 22% higher than in 1976 (Table 1), it appears that the increase has continued. However, only the two small colonies were completely surveyed, whereas the size of the primary colony was estimated from sampling procedures in both years. Although the confidence limits on the estimate for Egg River were narrow (± 12%) in 1981, definitive comparison with 1976 is hampered because confidence limits could not be calculated in 1976 (Kerbes 1983). Also, the proportion of breeding birds in the population is variable, and a higher proportion of the population may have nested in 1981 than in 1976.

Most non-breeders in the western Arctic spend the summer (after 15-24 June) on Banks Island, in areas separate from the nesting grounds at Egg River (T. W. Barry, personal communication). A small number were found on the nesting colonies that I photographed in 1976 and 1981. Egg River colony had proportionately fewer non-breeding birds than the two smaller colonies in 1976 (Table 2). That may have been due to a higher proportion of failed-breeding on the small colonies. In 1981 the three colonies had more similar ratios than in 1976. The proportion of non-breeders (6-8%) recorded at Egg River was similar to proportions found on the large eastern Arctic colonies in 1973 (3%-8%, Kerbes 1975).

Comparison of nesting distribution maps (Figures 1a, 1b, 2a, 2b, 3a, 3b) showed dramatic differences

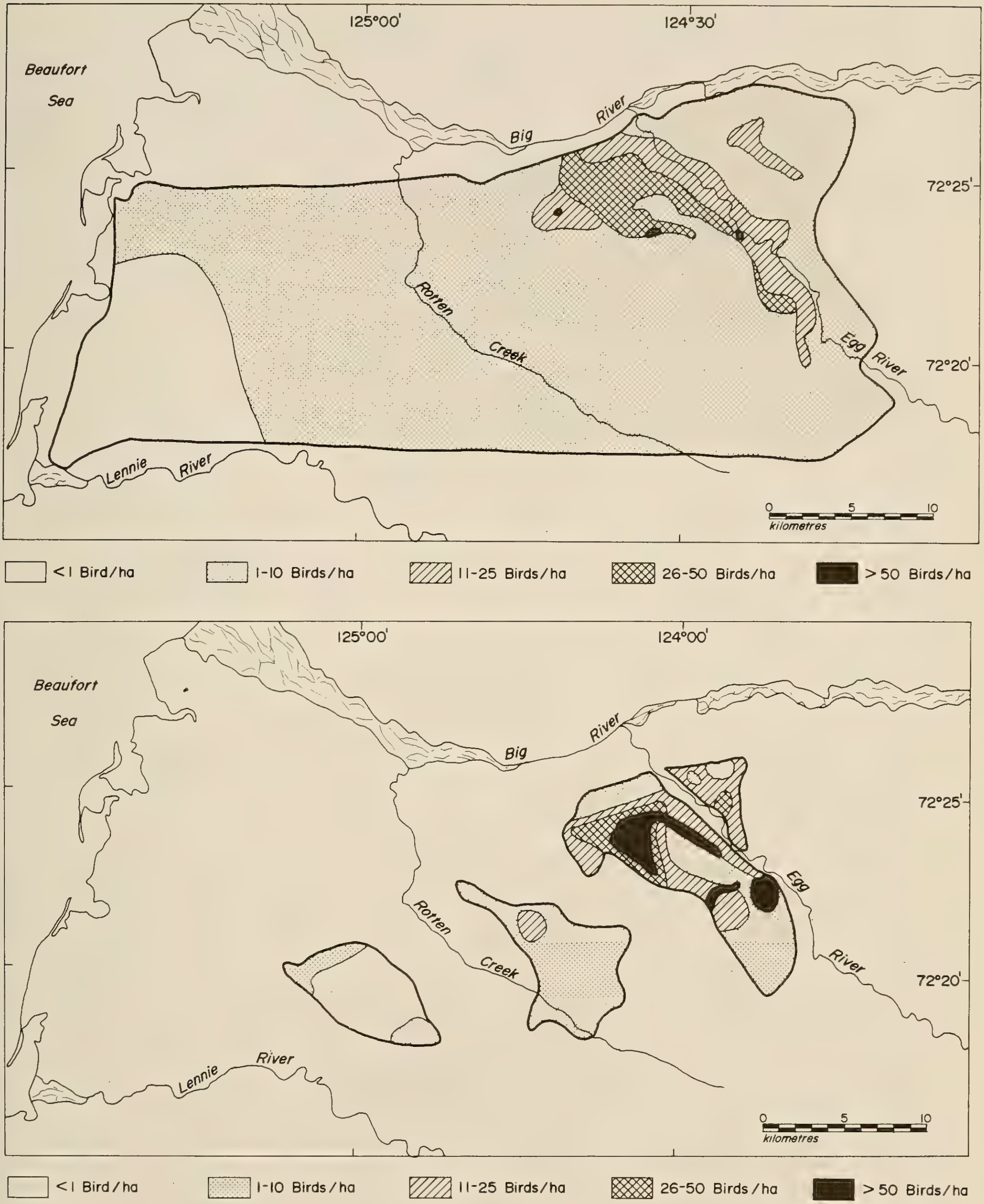

FIGURE 1. Lesser Snow Goose colony at Egg River, showing the density of nesting birds, (a) *above* June 1976, and (b) *below* June 1981.

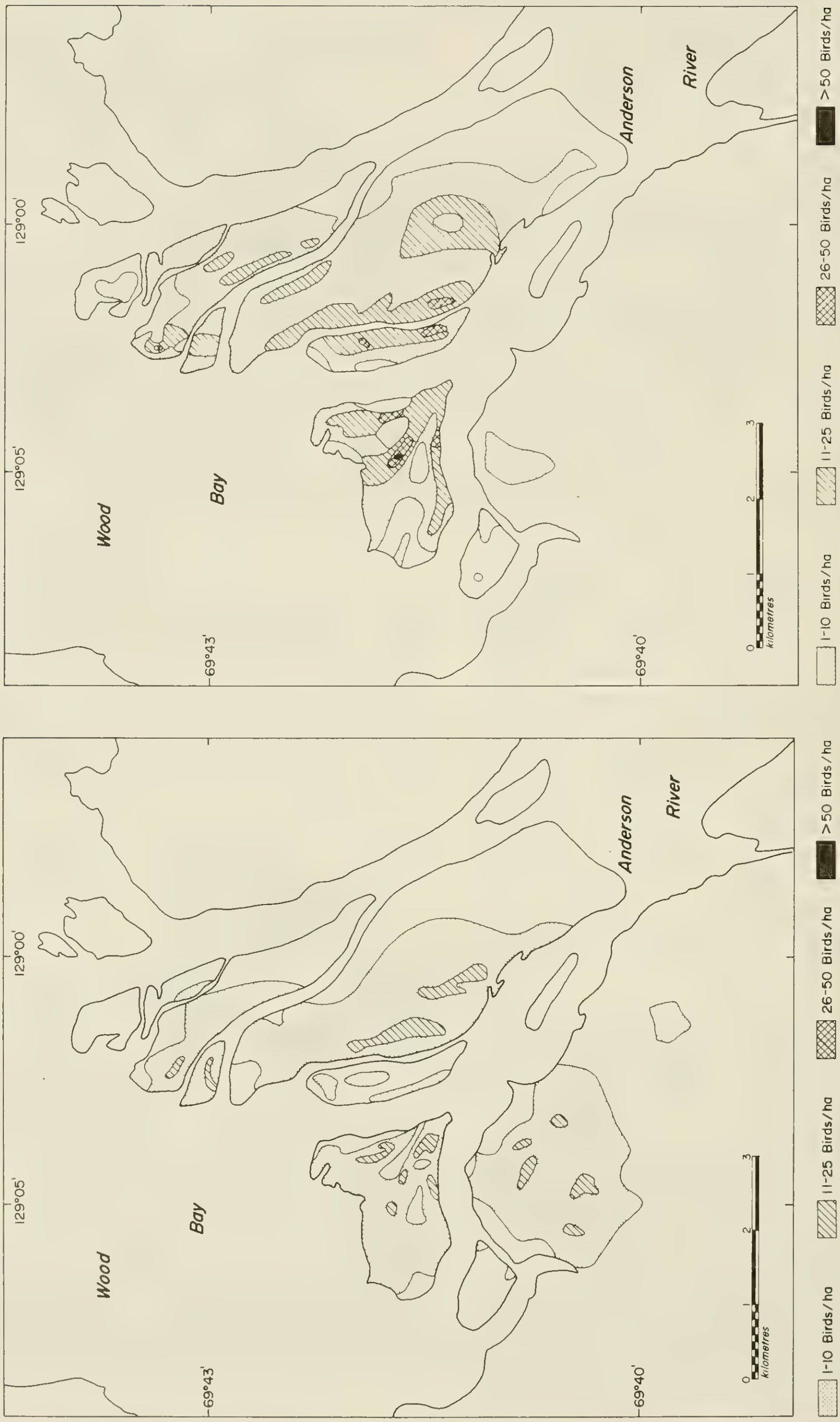

FIGURE 2. Lesser Snow Goose colony at Anderson River, showing the density of nesting birds, (a) *left* June 1976, and (b) *right* June 1981.

FIGURE 3. Lesser Snow Goose colony at Kendall Island, showing the density of nesting birds, (a) *above* June 1976, and (b) *below* June 1981.

TABLE 1. Photographic inventories of Lesser Snow Goose colonies in the western Canadian Arctic, June 1976 and 1981.

	11–13 June 1976[1]			13 June 1981		
Colony	No. nesting pairs	Total nesting area, km² (% analyzed on photos)	Mean density nests per ha	No. nesting pairs	Total nesting area, km² (% analyzed on photos)	Mean density nests per ha
Egg River	82 511[2]	605.3 (16)	1.36	99 063[3]	169.2 (33)	5.85
Anderson River	1 913	15.5 (100)	1.23	4 180	16.9 (100)	2.47
Kendall Island	416	6.2 (100)	0.67	521	2.6 (100)	2.00
Total	84 840	627.0	1.35	103 764	188.7	5.50

[1]From Kerbes (1983).
[2]Confidence Limits not calculated (see text).
[3]95% Confidence Limits were 87 126 to 110 999.

TABLE 2. Percentage of non-breeders among Lesser Snow Geese counted from aerial photographs of the nesting colonies, western Canadian Arctic, 1976 and 1981.

	11–13 June 1976		13 June 1981	
Colony	% Non-breeding (sample size)	Total Geese[1]	% Non-breeding (sample size)	Total Geese[1]
Egg River	6 (42 007)	175 555	8 (93 591)	215 354
Anderson River	21 (4 843)	4 843	10 (9 238)	9 238
Kendall Island	47 (1 577)	1 577	10 (1 153)	1 153
Total, weighted by colony size[2]	7	181 975	8	225 745

[1]Breeding birds plus non-breeders. [2]Percentage from sample applied to estimated total birds in each colony.

between years, especially at the Egg River colony. In 1981, the Egg River colony covered approximately one-quarter of its 1976 area; nevertheless it had 20% more nesting birds owing to much higher densities. In 1976 spring arrived early, with virtually no limits to nesting imposed by snow cover (T. W. Barry, personal communication). In 1981 spring was late, with nesting restricted to the few areas which cleared early enough to allow nesting. The areas occupied in 1981 tended to be the same areas which had the highest densities of 1976. Therefore, areas of high nest density probably reflect the locations which are most consistently free of snow early in the nesting season.

Snow Geese from the western Canadian Arctic winter in California and, to a lesser extent, in New Mexico and the adjacent highlands of Mexico (Dzubin 1979). In northern California, they are joined by Snow Geese from the colony on Wrangel Island, USSR, and in New Mexico and northern Mexico by some Snow Geese from the central Canadian Arctic colonies (Dzubin 1979). Also, they share their wintering grounds with similar-looking Ross' Geese (*Anser rossii*) from the central Canadian Arctic (McLandress 1979; Melinchuk and Ryder 1980). Thus, a census of the population in winter is complicated by uncertain proportions from other white goose stocks. Furthermore, the visual aerial surveys of the mid-winter inventory do not give accurate results, particularly for the numbers and proportions of Snow and Ross' geese in California (McLandress 1979). I conclude that monitoring of the western Arctic Snow Goose population is best conducted on the nesting colonies.

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The Effects of Pipelines, Roads, and Traffic on the Movements of Caribou, *Rangifer tarandus*

JAMES A. CURATOLO and STEPHEN M. MURPHY

Alaska Biological Research, P.O. Box 81934, Fairbanks, Alaska 99708

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The frequency of Caribou, *Rangifer tarandus*, crossings of roads, pipelines, and pipelines along roads was studied in the Prudhoe Bay and Kuparuk oil fields on the Arctic Coastal Plain of Alaska. Caribou crossed an elevated pipeline or a road with a frequency similar to the control. It was only where a pipeline paralleled a road with traffic, that crossing frequencies were significantly less than expected (30% versus 66%). It is postulated that vehicles act in a synergistic fashion with a pipeline to produce a negative stimulus that results in decreased crossing frequency. Caribou crossing under elevated pipelines did not select for particular pipe heights within the range studied (152–432 cm). Caribou did select buried sections of pipeline as crossing sites more often than expected.

Key Words: Caribou, *Rangifer tarandus*, pipeline, road, oil development, Alaska.

The Central Arctic Caribou (*Rangifer tarandus*) Herd (CAH) ranges on the north slope of the Brooks Range between the Canning and Colville rivers (Cameron and Whitten 1979). The majority of the CAH remain on the Arctic Coastal Plain during summer, where they travel to the coast during periods of mosquito (*Aedes* spp.) harassment and move inland during mosquito-free periods (White et al. 1975). This movement pattern regularly brings the CAH into areas of oil development.

The most recent expansion of oil development on the North Slope of Alaska has been in the Kuparuk River Oilfield and western end of the Prudhoe Bay Oilfield, approximately 40 km west of Prudhoe Bay and within the summer range of the CAH. Development has been proceeding rapidly there since 1978 and has included construction of the Kuparuk Pipeline, a 40 km, east-west oriented, 40 cm diameter elevated pipeline. This pipeline and an expanding network of feeder pipelines intersect the summer movements of the CAH.

In 1980 the State of Alaska required that the minimum pipeline height be 1.5 m in the Kuparuk River Oilfield to allow for free passage of Caribou. At that time no quantitative data were available to substantiate the effectiveness of this stipulation. In 1981 studies were initiated by the oil industry to determine if this criterion was an effective mitigative measure and to gain insight into the reactions of Caribou to pipelines for future oilfield planning.

This report discusses the frequency that Caribou crossed pipelines and roads, whether pipeline height affected selection of crossing sites, and whether ramps (i.e. buried sections of pipeline) were preferentially used as crossing sites.

Study Area and Methods

This study was conducted near the Kuparuk and Ugnuravik rivers in Alaska, 10–20 km south of the Beaufort Sea coast (Figure 1). This region, dominated by wet sedge (*Carex* spp.) tundra and nearly flat except for pingos, river banks, and man-made structures, is typical of the Arctic Coastal Plain. Geobotanical aspects of the region are described by Walker et al. (1980).

Seven study sites ranging in size from 180 to 275 hectares (Figure 1) were used between 1981 and 1983, although not all study sites were used every year. Site 1 was used in 1981 and 1982; its northern border was an elevated pipeline (range 152–279 cm) adjacent to a road with traffic. Site 2 was used in 1983, and its northern border also consisted of an elevated pipeline (range 119–229 cm) adjacent to a road with traffic. Site 3 was used in 1981 through 1983; its northern border was an elevated pipeline (152–432 cm) adjacent to a construction pad with no traffic. Site 4 was used in 1983, and had as its northern border a high elevated pipeline (>650 cm) with no adjacent road. Site 5 was used in 1982 and was bounded on the north by a road with traffic. Sites 6 and 7 were used in 1981 and 1982; the northern borders of these sites were hypothetical pipelines consisting of a line of orange stakes placed at 50 m intervals. Three of the study sites (Sites 1–3) also had ramps (sections of buried pipe that were 50, 30, and 20 m wide, respectively).

Data were collected during the insect season: 2 July to 5 August 1981, 29 June to 1 August 1982, and 25 June to 29 July 1983. Variable-power spotting scopes and binoculars were used to observe Caribou from 3 m high towers. Observation times were not set; rather an effort was made to observe Caribou,

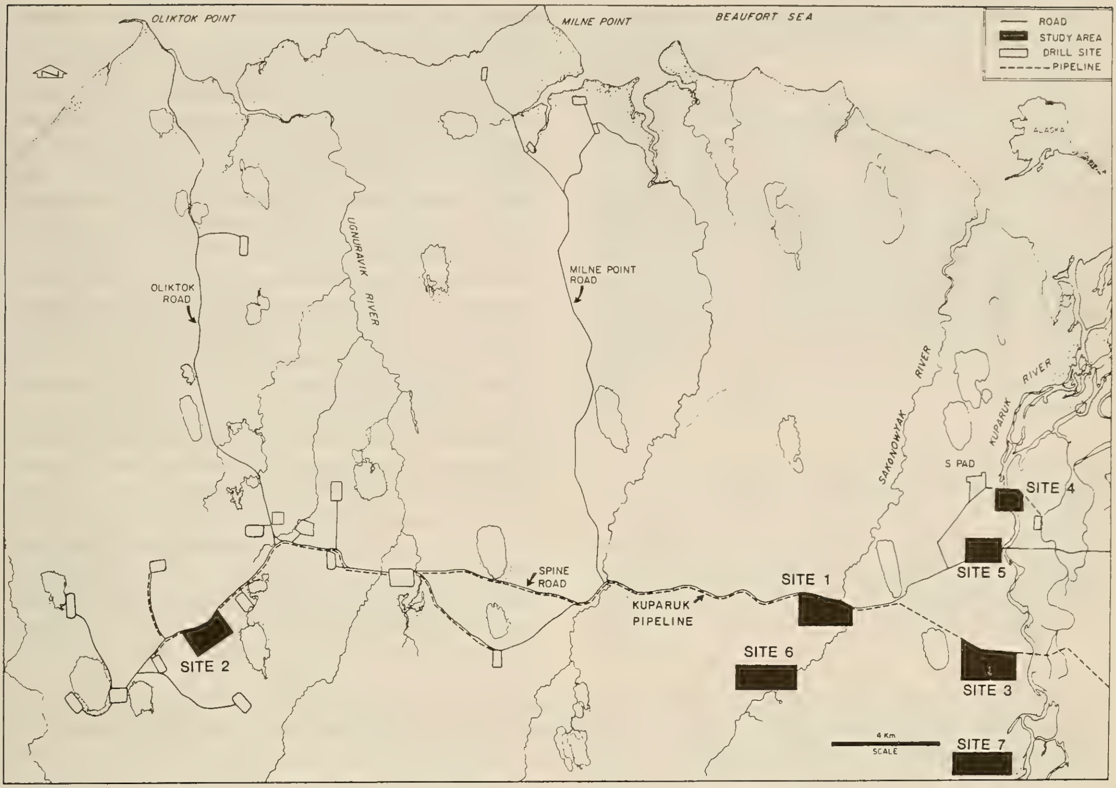

FIGURE 1. Location of study areas near the Kuparuk and Ugnuravik rivers in Alaska. Sites 1 and 2 are bounded by a pipeline adjacent to a haul road with traffic, site 3 is bounded by a pipeline adjacent to a construction pad with no traffic, site 4 is bounded by a pipeline, site 5 includes a haul road with traffic, and sites 6 and 7 are controls.

rather an effort was made to observe Caribou when they were in the vicinity and for as long as they were present. Data collected included group size, group composition (cow, calf, yearling, bull), route of travel through the study site, reactions of Caribou while crossing a road or pipeline, and number of vehicles in the study site. In addition, 10-minute point-in-time scans were taken of air temperature, wind speed, and insect presence. The presence (moderate/severe) or absence (none/light) of mosquitoes was determined using the relationship between mosquito activity and temperature and wind speed developed by White et al. (1975). The presence of oestrid flies was determined by observation of stereotyped behavioral responses to oestrids exhibited by Caribou, such as wild running (Curatolo 1975) and rigid standing (Espmark 1968) or by direct observations of flies. A severe reaction was recorded when caribou moved away from a disturbance at a trot or run. Severe reactions were distinguishable from ongoing activities, such as running induced by mosquitoes. Crossings of groups rather than individuals were selected for analyses because groups generally behaved as a cohesive unit. Crossing frequencies of individuals are also included for comparison.

Pipeline height was measured from the bottom of the pipe to the ground at each vertical support member (VSM). Caribou crossing between any two VSMs were recorded as having crossed under the pipeline at the mean height of those VSMs. All VSMs were numbered to locate crossing sites of Caribou. A Caribou group was arbitrarily considered to have crossed a pipeline successfully when >50% of the group crossed.

Observations of Caribou crossing pipelines and/or roads were classified according to the presence or absence of mosquitoes and oestrid flies to determine the effect these insects have on crossing frequency. Crossings by Caribou were also classified as either

southbound or northbound because mosquitoes caused highly directional movements during most of the field season.

Chi-square analysis was used to test whether pipeline crossing frequencies at experimental sites were different from expected, based on crossing frequencies of northern borders (hypothetical pipelines) in the controls. Only complete data sets were used for analysis (e.g. caribou observed entering and exiting study sites). The log-likelihood ratio for contingency tables (Zar 1974) was used where expected values were small, such as the frequency of ramp crossings; and the Mann-Whitney Test was used to test differences in pipe height selection. Significance was evaluated at the 95% confidence level.

Results and Discussion

Frequency of Caribou Groups Crossing Pipelines and Roads

Caribou movement patterns and the relative number of Caribou groups traveling north or south across the northern border (e.g. pipeline) of the study sites appeared to be highly dependent on insects (Table 1). For example, when insects were not present, Caribou going south accounted for 77% of all crossings of the northern border of the controls. When mosquitoes were present, Caribou traveling north accounted for 80% of all crossings of the northern border of the controls. These patterns reflect the movements of Caribou during the summer, when Caribou, harassed by mosquitoes, travel north to the coast for relief and return south when mosquito activity declines (White et al. 1975).

Caribou groups tended to exhibit non-directional movements when oestrid flies were present. This is characteristic behavior during fly harassment (Curatolo 1975; Thomson 1971). Caribou near pipelines also had a propensity to seek relief from flies in the shade of the pipeline in a manner similar to reindeer using the shade of trees (Espmark 1968). Caribou tended to ignore the pipeline and traffic when standing in the shade or, at most, tended to run short distances when chased by flies or startled by vehicles. Repeated crossings of the pipeline were common when flies were present as Caribou weaved back and forth under the pipe, resulting in multiple crossings of at least 37 groups (39%). Therefore, the north and

TABLE 1. Per cent of Caribou groups that crossed the northern border of the study sites, which consisted of a pipeline, road, pipeline/road, or a hypothetical pipeline. More than 50 per cent of a group had to cross to be considered successful.

	Structure					
Insects Present	Pipeline/ Road Site 1	Pipeline/ Road Site 2	Pipeline Site 3	Pipeline Site 4	Road Site 5	Control Sites 6,7
None						
Total number groups	43	18	180	21	24	75
Southbound	16%*	11%*	61%	38%	42%	51%
Northbound	21%	22%	14%	14%	4%	16%
Total crossings	37%*	33%*	75%	52%	46%	66%
Mosquitoes						
Total number groups	45	9	118	23	27	61
Southbound	2%*	0	10%	0	0*	13%
Northbound	29%*	0*	58%	65%	100%*	51%
Total crossings	31%*	0*	68%	65%	100%*	64%
Oestrid Flies						
Total number groups	24	17	55	—	—	54
Southbound	54%	6%	9%	—	—	11%
Northbound	25%	35%	62%	—	—	56%
Total crossings	79%	41%	71%	—	—	67%
Overall						
Total number groups	112	44	353	44	51	190
Total crossings	44%*	30%*	72%	59%	75%	66%
Total number individuals	2014	1151	9846	2834	3325	2742
Total crossings	30%	5%	72%	57%	78%	61%
Traffic level (vehicles/hour)	moderate (15)	high (30)	very light (<0.1)	none (0)	moderate (15)	none (0)

*Indicates crossings significantly different from controls; only total crossings were tested for oestrid flies.

south crossing frequencies were not tested for the oestrid fly data because they did not adequately describe crossings during this period; most movements were non-directional.

Crossing frequencies similar to the controls were observed at the pipeline study sites (Sites 3 and 4) and the road study site (Site 5) when insects were not present and when mosquitoes were present. There were no significant differences between these sites and the controls, except that crossing frequency over the road was significantly greater than the control when mosquitoes were present. On the other hand, crossings at the pipeline/road study sites (Sites 1 and 2) were significantly lower than the controls during both of these periods, and the pattern of northbound and southbound movements were similar to the controls only when mosquitoes were present. The frequencies of total crossings at all of the pipeline and pipeline/road study sites were not significantly different from those of the controls during periods of oestrid fly harassment (Table 1).

Sixty-two per cent of the Caribou (n = 262) reacted severely (i.e. running) when crossing the pipeline/road at Site 1 compared to 47% crossing the road at Site 5 (n = 5106), 12% crossing the pipeline at Site 3 (n = 4371), and 10% crossing the pipeline at Site 4 (n = 4453). The high frequencies of severe reactions at the pipeline/road and at the road study areas provide evidence that Caribou respond to moving stimuli. A high frequency of severe responses to traffic (not associated with a pipeline) was also observed by Horesji (1981). However, because traffic usually is a transient stimulus, Caribou movements are not necessarily affected when no other structures are present.

We attribute the lower crossing frequency at the pipeline/road sites to the combination of vehicular traffic and a pipeline. Indeed, crossing frequency was lowest where traffic adjacent to an elevated pipeline was highest (1 vehicle every 1.9 minutes at Site 2 versus 1 vehicle every 3.9 minutes at Site 1). These observations may be best interpreted in terms of inherent behavioral traits of Caribou. Caribou evolved in open habitats with wolves as their major predator (Bergerud 1974). Thus, Caribou tend to avoid or be more alert in habitats that can conceal a predator (Curatolo 1975).

It seems that the frequency of traffic along a pipeline is important because Caribou must have sufficient time between vehicle encounters to successfully cross both the pipeline and the road. As Caribou approach an elevated pipeline, they usually hesitate up to 10 minutes before crossing, whether or not vehicles are present. A passing vehicle usually causes Caribou to retreat from the pipeline or, at least interrupts their attempt to cross. Thus, as traffic levels increase, opportunities for Caribou to cross the pipeline decrease.

Influence of Group Type and Group Size on Crossing Frequencies

Within each study site there was no significant difference between the percentage of cow-calf groups and bull groups that crossed the pipeline (Table 2). Other studies have identified cow-calf groups as the most sensitive segment of the herd (Bergerud 1974; Curatolo 1975; Roby 1978). The Kuparuk Pipeline traverses important routes to mosquito relief habitat. The similarity of crossing frequencies between bull and cow-calf groups in our study may be a result of the intensity of the drive to reach mosquito relief habitat on the coast.

There was a tendency for large groups (> 100) to be less successful than small groups (< 100) when crossing the pipeline/road within Site 1 or Site 2, although no significant differences were found (Table 2). Crossing frequencies for individuals were also lower than for groups at these sites (Table 1), suggesting that large groups were less successful than small groups.

In summer, Caribou usually form large groups during periods of mosquito harassment (Curatolo 1975); indeed the largest groups form during times of the most severe harassment. These large groups have a greater probability of containing some individuals that are more easily disturbed than others; this may, in turn, affect the behavior of the entire group. Large groups take more time to cross a pipeline than small groups, and this delay increases the potential for encounters with traffic. Thus, traffic along a pipeline may contribute to the lower crossing success of large groups that we observed.

There were no differences in crossing frequencies between large and small groups within sites with only a pipeline. In contrast, Child (1974) concluded that small groups crossed his simulated pipeline (no vehicular traffic) more often than large groups. It may be that Child's simulation was more disturbing to large groups (already under mosquito harassment) than the Kuparuk Pipeline or that sufficient habituation has occurred so that the pipeline we observed was no longer a disturbing factor.

Pipe Height Selection

Clearance of the elevated pipeline ranged from 152–432 cm at the three study areas where data on crossing site selection by Caribou groups were collected (Table 3). The mean pipeline height of crossing sites selected by Caribou at both pipeline/road study sites (Sites 1 and 2) did not differ significantly from the mean pipe height available. In

TABLE 2. Pipeline and pipeline/road crossing frequencies by group size and group type.

		Group type[1]				Group size			
Study Area	Year	cow-calf	n	bull	n	<100	n	≥100	n
Pipeline/road (Site 1)	1981-1982	49%	58	38%	47	45%	107	20%	5
Pipeline/road (Site 2)	1983	24%	33	36%	11	30%	43	0%	1
Pipeline (Site 3)	1981-1983	71%	112	75%	202	72%	325	75%	28
Pipeline (Site 4)	1983	57%	21	67%	21	56%	36	75%	8
Control (Sites 6 and 7)	1981-1982	59%	81	71%	94	66%	185	60%	5

[1]More than 50 per cent of the Caribou in the group were either bulls or cows and calves; excludes individuals and cow-yearling groups.

1981, but not in 1982 or 1983, the mean pipeline height of crossing sites selected by Caribou at the pipeline study site (Site 3) was significantly higher than the mean pipe height available (Table 3).

There are no other quantitative studies for comparison with these data. The fact that Caribou selected for higher pipe heights only one year out of three suggests that pipe height is not an important factor in crossing site selection within the range of pipe heights we studied. Pipeline heights above 1.5 m are largely determined by topographic variations and it appears that normal movement patterns along certain topographic features (e.g., river drainages) probably account for the crossings observed under

TABLE 3. Mean heights of elevated pipeline available for crossing compared with mean heights of pipeline selected by Caribou for crossing.

Location	Type of Data	Year	Mean (cm)	SD	Range (cm)	n[1]
Pipeline/road (Site 1)	actual pipeline	—	186	27	152-279	168
	Caribou crossings	1981	188	29	152-279	92
	Caribou crossings	1982	183	23	152-279	78
Pipeline/road (Site 2)	actual pipeline	—	182	16	119-229	92
	Caribou crossings	1983	184	20	149-227	36
Pipeline (Site 3)	actual pipeline	—	261	65	152-432	139
	Caribou crossings	1981	301	70	152-432	138
	Caribou crossings	1982	274	66	152-432	345
	Caribou crossings	1983	278	68	152-432	184

[1]This number represents the number of VSMs in the actual pipeline in the study site or the number of crossings made by Caribou in the study site. A "crossing" consisted of one or more Caribou crossing under a pipeline between two adjacent VSMs in a more or less cohesive manner. Thus, one Caribou group can account for one or more crossings.

higher pipe heights. It is also possible that habituation may account for the lack of selection of high pipeline in the last two years of the study. A pipeline is a stationary structure, and is a relatively low level stimulus compared with a pipeline adjacent to a road with moving vehicles. Perhaps Caribou crossed under the high pipeline in 1981 (the first year the pipeline was in place) because it was less frightening than crossing under low pipeline sections. If this is so, it appears Caribou readily habituated, as there was no apparent selection for high pipeline in the following two years. On the other hand, the lack of selection of high pipeline in the pipeline/road site during any year (Table 3) may be explained by the additional disturbances caused by traffic at that site and by the lack of prominent topographic features for Caribou to follow.

Use of Ramps as Crossing Sites

Pipeline crossings were classified as either crossings under an elevated pipeline or crossings over a ramp (buried pipeline) to determine whether Caribou preferred specific pipeline configurations for crossing sites (Table 4). Six per cent, twelve per cent and nine per cent of the crossings at Sites 1, 2, and 3, respectively, were over ramps. These crossings were significantly more frequent than expected because the buried pipe constituted less than 2% of the pipeline at these sites. A preference for ramps was also observed in Prudhoe Bay in 1972 (Child 1974). Child found that 76% of the Caribou crossing a simulated pipeline crossed over ramps that represented 22% of the total length of the simulation.

The preference for ramps as crossing sites by Caribou appears to reflect the effect of elevated pipelines on Caribou behavior. Caribou tend to follow linear structures for some distance before crossing (LeResche and Linderman 1975). When Caribou encounter an elevated pipeline they may parallel it even though that may entail a change in the direction of travel. Upon reaching a ramp, the visual stimulus of the elevated pipeline is gone; this may provide a "path of least resistance" for Caribou to follow.

Summary and Conclusions

The frequency of crossings by Caribou of a pipeline adjacent to a road with traffic during both insect-free periods and periods of mosquito harassment was significantly less than expected. There was no significant difference when oestrid flies harassed Caribou. Our studies suggest that Caribou react to two types of stimuli in an oilfield: structures possibly resembling concealing habitat (e.g. raised pipeline) and moving objects possibly resembling predators (e.g. vehicles). It was only when Caribou observed these stimuli together (i.e. a pipeline adjacent to a road with traffic) that there was a significant decrease in the percentage of Caribou crossings.

Caribou readily crossed under an elevated pipeline or over a road. The ability of Caribou to cross a single structure (e.g. pipeline) compared to multiple structures (e.g pipeline and road) suggests that separation of roads and pipelines would facilitate Caribou movements in areas of oil development.

There did not appear to be selection for particular pipeline heights within the range we studied (152–432 cm), regardless of the traffic level. Therefore, it appears that the 150 cm minimum pipeline height that was required by the State of Alaska is adequate for Caribou passage.

There was a preference for ramps as crossing sites, although the crossing frequency was low. We doubt that any type of special crossing structure would be able to lessen the impact on Caribou when traffic levels are very high (i.e. one vehicle every two minutes). It may be that ramps do not function effectively under heavy traffic conditions during oilfield construction. Rather, ramps may be more applicable once the oilfield is in production and traffic levels decrease.

TABLE 4. A comparison between the number of ramp crossings[1] and the number of elevated pipeline crossings by Caribou groups, observed in three different locations along the Kuparuk Pipeline, Alaska.

Structure	Year	Ramp crossings		Elevated pipeline crossings	
		Observed	Expected	Observed	Expected
Pipeline/Road Site 1	1981-1982	10	1.07	170	178.93
Pipeline/Road Site 2	1983	5	0.85	36	40.15
Pipeline Site 3	1981-1983	65	5.27	667	726.73

[1]A "crossing" consisted of one or more Caribou crossing under a pipeline between two adjacent VSMs or over a ramp in a more or less cohesive manner. Thus, one Caribou group can account for one or more crossings.

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Dietary Overlap in Sympatric Populations of Pygmy Shrews, *Sorex hoyi*, and Masked Shrews, *Sorex cinereus*, in Michigan

JAMES M. RYAN

Museum of Zoology and Department of Biological Science, University of Michigan, Ann Arbor, Michigan 48109
Present Address: Department of Zoology, University of Massachusetts, Amherst, Massachusetts 01003-0027

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Summer (15 May-20 August) foods of 29 Pygmy Shrews (*Sorex hoyi*) and 31 Masked Shrews (*Sorex cinereus*) were examined in seven bog/peatland habitats in northern lower Michigan. Ants accounted for 45.5% and 50% of the prey items found in the stomach and intestinal tracts of Pygmy and Masked shrews, respectively. Non-formicid Hymenoptera, Arachnida, Coleoptera, and Lepidoptera larvae made up the remainder of the diet of both shrew species. Both Pygmy and Masked shrews seemed to prefer prey less than 5 mm in total body length. Data from this study indicate that there is a high degree of dietary overlap between sympatric populations of Pygmy Shrews and Masked Shrews in Michigan.

Key Words: Pygmy Shrew, *Sorex hoyi*, Masked Shrew, *Sorex cinereus*, diet, foods, bog, Michigan.

The Pygmy Shrew, *Sorex hoyi*, is among the rarest of North American small mammals, while the Masked Shrew, *Sorex cinereus*, is among the most abundant. The Pygmy Shrew ranges from Alaska to Labrador and south in mountains to Colorado and North Carolina (Long 1974; van Zyll de Jong 1983). Recently, the range of the Pygmy Shrew was found to include the northern third of the lower peninsula of Michigan (Rabe 1981; Ryan 1982). The slightly larger Masked Shrew occurs throughout much of North America (Hall 1981). At scattered localities throughout most of northern Michigan and elsewhere in boreal North America, Masked Shrews and Pygmy Shrews occur sympatrically.

An important factor in the coexistence of these two species may be dietary relationships. If food resources are limited, it is likely that these two morphologically similar species partition food resources so as to avoid competition. The diets of Masked Shrews are known from several habitats (Hamilton 1930; Buckner 1959, 1964; Holling 1959; Whitaker and Mumford 1972; Criddle 1973; French 1984); however, the diets of free-ranging Pygmy Shrews are almost unknown (Whitaker and French 1984).

The objective of this study was to document the diets of these two shrew species in areas where they occur sympatrically, to assess the degree of dietary overlap, and to determine if availability of prey in the field or prey size influenced the diet of either species.

Study Area and Methods

Pitfall trapping (3466 trap nights) was conducted from 15 May to 20 August 1981 at the following locations in the northern part of the lower peninsula of Michigan (44°30′N, 46°N, and 84°W, 85°W) — *Cheboygan Co.*: Dingham Marsh (DM), Lake Sixteen (L16), Dog Lake Flooding (DLF); *Crawford Co.*: Connor's Flat Bog (CFB); *Montmorency Co.*: Twin Tomahawk Lakes (TTL); *Otsego Co.*: Tin Shanty Bog (TSB) and Turtle Creek Bog (TCB). The seven study areas varied in the density and composition of the overstory, shrub layer, soil moisture, and depth and composition of the peat layer. The dominant vegetation at all sites consisted of clumps of Black Spruce (*Picea mariana*), Tamarack (*Larix laricina*), and occasionally White Pine (*Pinus strobus*) or Jack Pine (*Pinus banksiana*). The understory was composed of a thick shrub layer of leatherleaf (*Chamaedaphne* spp.) and other bog shrubs, occasional openings with sedges (*Carex* spp.) and always a thick *Sphagnum* moss mat. All study sites are characterized as bogs or peatlands in various stages of ecological succession (Gates 1942).

Pygmy and Masked shrews were trapped using 800 mL plastic beakers set as pitfalls. Each pitfall contained approximately 10 cm of 10 percent formalin to prevent decomposition and further digestion of the stomach contents. Pitfalls were used because they have been found to be more effective than other traps in sampling shrew populations (Prince 1941; MacLeod and Lethiecq 1963; Pucek 1969). Pitfall traps also served to collect a reference sample of invertebrates from each site. At the end of each trapping session invertebrates from all traps at a site were combined, identified to order, and divided into size classes based on total body length.

Because small shrews (3-7 g) have relatively little, highly masticated material in their stomachs, the material from stomachs and intestinal tracts was considered together. Including material from intestinal

tracts may underestimate softer food items (i.e. larvae) due to the differential digestion of harder vs. softer items in the stomach and especially the intestines. Gut samples were examined in shallow petri dishes and compared with invertebrate reference slides, taken at the field sites, using both compound and binocular dissecting microscopes. Gut contents consisted of many unidentifiable fragments of chitin and only identifiable parts (leg segments, antennae, mandibles, wings, etc.) were used in this study to determine the presence or absence of an invertebrate order in the gut sample. In addition, two slides were made from the supernatant liquid of each gut sample and examined in their entirety for plant material, including fungal spores.

To compute dietary overlap (O) between the two shrew species, the lower of two paired percent values for each prey item (p_{min}) was summed over all *n* food categories and divided by 100 (Findley and Black 1983).

$$O = \frac{\sum_{i=1}^{n} p_{min}}{100}$$

A similarity coefficient (Smith 1980) was used to compare similarity in the distribution of invertebrate prey in the field with the distribution of prey in shrew diets. This coefficient is C = 2w/a+b, where w = the sum of the lower of the two paired % values for each prey item, a = the sum of all the % values for the first species, and b = the sum of the % values for the second species. Values of both O and C range from 0, no similarity, to 1, identical diets.

Results

Stomachs and intestinal tracts of 29 Pygmy Shrews (12 F, 15 M, and 2 juveniles) and 31 Masked Shrews (16 F, 13 M, and 2 juveniles) collected in bog habitats in northern lower Michigan were examined (Table 1). Ants accounted for 45.5% and 50% of the total number of identifiable prey items found in gut samples of Pygmy and Masked shrews, respectively. However, ants are small relative to many other invertebrates (2 to 5 mm) and may make up only a fraction of the total volume of diet. Typically, gut samples contained only one or two invertebrate prey items due to the small size of the digestive tracts. Non-formicid Hymenoptera, Arachnida, Coleoptera, and Lepidoptera larvae made up the majority of the remaining diet of both species. Collembola, Diptera, and Homoptera accounted for less than 10% of the prey items of both shrews. No plant material of any kind was found in the gut samples. The dietary overlap coefficient (O) for taxonomic orders of invertebrates between Pygmy Shrews and Masked Shrews was O = 0.83.

TABLE 1. Number and percent of prey items identified from the stomach and intestinal tracts of Pygmy Shrews (*Sorex hoyi*) and Masked Shrews (*Sorex cinereus*) from northern lower Michigan.

	S. hoyi (n = 29)		*S. cinereus* (n = 31)	
Prey Item	# of items	% of items	# of items	% of items
Hymenoptera (ant)	15	45.5	15	50.0
Hymenoptera (other)	5	15.5	5	16.7
Arachnida	4	12.0	6	20.0
Lepidoptera larvae	3	9.1	2	6.7
Coleoptera adult	3	9.1	1	3.3
Collembola	2	6.1	0	—
Diptera adult	1	3.0	0	—
Homoptera	0	—	1	3.3

Hymenoptera (primarily ants) and Arachnida (primarily spiders) accounted for 50% or more of the number of invertebrates taken in pitfall traps at each study area (Table 2). The similarity coefficient between shrew diets and invertebrate field samples (total for all sites) was C = 0.76 for both Pygmy and Masked shrews.

Invertebrate field samples were grouped according to total body length (Table 3). Forty-six per cent of the invertebrates in these samples are from 2-5 mm in length. Hymenoptera accounted for over 60% of the diets of both shrew species and 73% of the 2-5 mm size class in the field samples. The second most common food of Pygmy and Masked shrews, Arachnida, were distributed in several size categories. Lepidoptera larvae and Coleoptera were mainly distributed in larger prey size classes. The remaining invertebrates were not common in the field samples or gut contents.

Discussion

Diets of captive Pygmy Shrews have been reported (Prince 1940). However, foods of free-ranging Pygmy Shrews are less well known (Hamilton and Whitaker 1979; Whitaker and French 1984; Haveman 1973).

Haveman (1973) examined digestive tracts of six Pygmy Shrews from the upper peninsula of Michigan and found them to contain Coleoptera, spiders, Diptera, and *Sphagnum* moss. Hamilton and Whitaker (1979) reported that the stomach of one Vermont specimen contained fragments of a small grub, earthworm, and several undetermined chitinous parts. Whitaker and French (1984) reported that insect larvae, Coleoptera, and spiders made up 94.3% by

TABLE 2. Number of invertebrates captured in pitfall traps for each study site that were also found as prey items in shrew gut content analyses.

	Trap sites*							
Invertebrates	L16	DLF	DM	TSB	TCB	TTL	CFB	All sites %
Hymenoptera	41	174	169	91	18	39	71	46.1
Arachnida	123	120	23	76	10	52	37	33.7
Lepidoptera (larvae)	29	11	40	5	1	10	6	7.8
Diptera adult	8	0	20	0	5	15	17	5.0
Coleoptera adult	8	32	2	5	3	10	3	4.8
Collembola	0	0	11	15	2	4	2	2.6
Homoptera	0	0	0	0	0	0	1	0.08
Trapnights	1099	1036	224	476	165	242	224	3466

*Abbreviations for trap sites appear in text.

TABLE 3. Percent frequency of potential invertebrate prey (from pitfall samples) for all study sites arranged by size class.

	Size Class				
Prey	< 2 mm %	2-5 mm %	6-10 mm %	11-20 mm %	> 20 mm %
Hymenoptera	< 1	73	21	12	9
Arachnida	45	19	62	29	1
Lepidoptera larvae	—	< 1	6	28	74
Coleoptera adult	2	2	6	23	15
Collembola	43	—	—	—	—
Diptera adult	9	4	3	3	—
Hemiptera	< 1	2	3	7	1
All prey items	25	46	17	6	6

volume of the diets of 23 Pygmy Shrews from Sagamook Mountain, New Brunswick.

In the present study, Hymenoptera, Arachnida, Lepidoptera larvae, and Coleoptera accounted for over 90% of the identifiable prey items found in digestive tracts of both Pygmy and Masked shrews. Plant material has been reported as a food item in shrews (Hamilton 1930; Whitaker and Mumford 1972; French 1984; Whitaker and French 1984); however, no plant material was found in this study.

Dietary overlap coefficients (O) were calculated for Masked and Pygmy shrews from the data presented in Table 2 of Whitaker and French (1984) and Table 1 of this paper. Dietary overlap was higher in bog/peatland habitats (0 = 0.83) from this study than from coniferous/deciduous forests in New Brunswick (0 = 0.76). Both values suggest a high degree of overlap in Pygmy and Masked shrew diets. The apparent similarity in diet may be due to the broad food categories (taxonomic orders) used.

Yalden (1981) suggested that prey size is more important to shrews than the taxonomic category. Butterfield et al. (1981) also reported that the density of different size-classes of prey is thought to be important in determining the relative abundances of sympatric shrew species. In this study, invertebrates between 2 and 5 mm in length were the most abundant potential prey items (46%) over all sites. Hymenoptera accounted for 73% of the prey in the 2-5 mm size class and over 60% of the prey in digestive tracts of both shrew species studied. Results from this study are consistent with the hypothesis that prey size may be an important factor in determining the diets of coexisting Pygmy and Masked shrews.

The availability of prey may influence the diets of shrew species. The diets of two or more coexisting species could be essentially identical if availability alone determined food habits (Whitaker and French 1984). In the present study, the diets of Pygmy and Masked shrews were compared with the availability of

potential prey in the field using data for all sites combined from Table 2. The composition of prey from stomach samples was similar (C = 0.76) to the availability of those potential prey items in the field. Thus, data from this study also support the availability hypothesis.

Dietary overlap in morphologically similar and sympatric species suggests competition for prey is likely (French 1984). French (1984) reported broad overlap in the diets of the allopatric Southeastern Shrew (*Sorex longirostris*) and the Masked Shrew in Indiana (O = 0.77). French (1984) stated, "If these two species of shrew did not maintain an allopatric pattern of distribution, competition for food might result."

In the present study, Pygmy Shrews and Masked Shrews were often caught in the same pitfall on the same night, suggesting that the home ranges of one species overlap or include home ranges of the other species. Yet coexisting Pygmy and Masked shrews were found to have similar diets (O = 0.83) in bog habitats.

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The Brittle Prickly-pear Cactus, *Opuntia fragilis*, in the Boreal Forest of Southeastern Manitoba

K. A. FREGO[1] and R. J. STANIFORTH[2]

[1]Department of Botany, University of Manitoba, Winnipeg, Manitoba R3T 2NT
[2]Author to whom correspondence should be addressed.
[2]Department of Biology, University of Winnipeg, Winnipeg, Manitoba R3B 2E9

Frego, K. A., and R. J. Staniforth. 1986. The Brittle Prickly-pear Cactus, *Opuntia fragilis*, in the boreal forest of southeastern Manitoba. Canadian Field-Naturalist 100(2): 229–236.

The Brittle Prickly-pear (*Opuntia fragilis*) population of southeastern Manitoba consists of approximately 32 colonies within the Boreal Forest and Great Lakes-St. Lawrence forest regions on south-facing outcrops, on shores of rivers and lakes in the Rice, Wanipigow, Manigotagan, Winnipeg and Lake of the Woods river systems. None were found away from riparian outcrops, in the surrounding forest or on inland outcrops. It is likely that these colonies are relicts of a more widespread distribution which existed during the Altithermal grassland period (8000–4500 years B.P.) and that they have persisted on small, isolated xeric sites with long growing seasons.

Key Words: *Opuntia fragilis*, Brittle Prickly-pear, boreal forest, altithermal relict, distribution, Manitoba, habitat, origin.

The Brittle Prickly-pear (*Opuntia fragilis* (Nutt.) Haw.) is locally common on "dry prairies, sand hills and rocks" from British Columbia to northwestern Ontario, and southwards to northern California and northern Texas (Scoggan 1979). Colonies in Manitoba occur in two discrete habitats. Those in the south-west and south-central parts of the province inhabit dry sand hills and alkaline prairies (e.g. Spruce Woods Provincial Park, Pembina Hills), while those in the south-east are found in the largely coniferous, Boreal Forest zone (e.g. Whiteshell Provincial Park). Populations from the two habitats are separated by a band of mixed forest and agricultural land which is approximately 180 km wide and devoid of cactus colonies. The Boreal Forest colonies are of interest because environmental conditions in this area appear to contrast with the popular concept of cactus habitat, i.e. long, hot, dry summers, well drained warm soils, and sparcity of vegetation. Only one other colony of *O. fragilis* growing in a forest zone has been studied previously, and that was an isolated colony found near Kaladar, Ontario (Beschel 1967). Other species of *Opuntia*, mostly of the *O. compressa* complex, occur on isolated rock outcrops in the Eastern Deciduous Forest Zone of the southern and eastern United States (Nichols 1914; Whitehouse 1933; Harper 1939; McVaugh 1943; Keever et al. 1951; Winterringer and Vestal 1956). Studies on these colonies have been concerned primarily with successional sequences on the outcrops or with micro-evolution of plant populations on them.

The first report for a forest population of *O. fragilis* in Manitoba was by Jackson et al. (1922) for Waugh on the Ontario border. Lowe (1943) described the species as "frequent in the eastern area" but gave no locations. Scoggan (1957) added only one boreal colony (Falcon Lake). Love (1959) described *O. fragilis* as one of about 320 species "with western affinities" which came from the west, south-west or south into eastern Manitoba between 10 000 and 2000 years ago, during a warm climatic period.

The aims of this study are to report the distribution, habitat and status of *Opuntia fragilis* in southeastern Manitoba and to consider hypotheses which may account for its origin and distribution in this region.

Reproductive Biology

Brittle Prickly-pear is a decumbent stem succulent with clusters of up to 9 spreading barbed spines at the areoles (Figure 1). It propogates by means of seeds, and by fragmentation of the stem into individual units (called "pads"), each capable of rooting and starting a new colony (Benson 1974). However, colonies in southeastern Manitoba flower irregularly and fruits are sterile (personal observations). Intensive searches by the authors have failed to find seedlings. It appears that the Brittle Prickly-pear reproduces entirely by vegetative means in southeastern Manitoba.

Study Area

Boundaries of the study area (Figure 2) were set to include Brittle Prickly-pear sites listed by Scoggan (1957) and additional sites that had been brought to the authors' notice. This area forms part of the Boreal and Great Lakes-St. Lawrence forest Regions. Vegetation is heterogeneous and associated with a mosaic-like relief of low sandy and granitic ridges interspersed with bogs. Shallow dry soils support Jack Pine (*Pinus banksiana*) and aspen (*Populus tremuloides*) and deeper soils are dominated by White

FIGURE 1. *Opuntia fragilis*, Brittle Prickly-pear Cactus.

Spruce (*Picea glauca*), Balsam Fir (*Abies balsamea*) and Balsam Poplar (*Populus balsamifera*). The bogs are characterized by Black Spruce (*Picea mariana*), Larch (*Larix laricina*), Labrador Tea (*Ledum groenlandicum*) and peat mosses (*Sphagnum* spp.). Outcrop vegetation is variable, but is often dominated by Bearberry (*Arctostaphylos uva-ursi*), Blueberry (*Vaccinium myrtilloides*), mosses (*Hedwigia ciliata, Tortula ruralis, Polytrichum* spp.) and lichens (especially *Cladonia* spp.) Details of the climate and soils of the study area are given by Anonymous (1982a, 1982b), Hemmerick and Kendall (1972), and Smith and Ehrlich (1967), respectively.

Methods

Distribution

Distribution data for Manitoba (Figure 2) and Canada (Figure 3) were compiled by examination of herbarium material (UWPG, WIN, MMMN, DAO, CAN, WNRE, UBC, USAS, UVIC, V, ALTA, LEA, UAC, SASK, and SCS). In Manitoba this was supplemented by field observations and results of a poster survey of 77 settlements throughout rural Manitoba. Where possible, the existence of reported colonies was confirmed and collections made during the summers of 1979-1981. Voucher specimens were placed in herbaria at the Universities of Manitoba and Winnipeg.

Habitat

A habitat description was compiled from physiographic, soil, and vegetation data gathered from each of seven cactus sites (locations shown on Figure 2). Physiographic measurements were aspect, angle of slope, and vertical distance above water (all colonies were adjacent to water bodies). Two soil samples ($10 \times 10 \times 10$ cm each) were collected from beneath cactus colonies at each of the seven study sites. These were stored frozen before analysis. Conductivity, pH, organic content, and macronutrient concentrations were determined using the techniques of McKeague (1978). Bulk densities were calculated using the equation of Jeffrey (1970). Vegetation was sampled between 8 July and 26 August 1980 by recording per cent cover of plant species at two locations at each of the seven sites. Nested quadrats of 0.09 m^2 (0.03×0.03 m), 1.0 m^2 (1×1 m), and 16 m^2 (4×4 m) were used to detect microcommunities of thallophytes, herbs/forbs, and chamae-/phanerophytes, respectively (Kershaw 1973). These procedures and sample sizes were based on those used by Limbird et al. (1980). The number of cactus colonies per site and the number of pads per colony at each site were recorded. Colony size was tested for correlation with soil characteristics using Pearson's product-moment correlation coefficient (Sokal and Rohlf 1969). Recent history of any disturbance was obtained from local residents. Adjacent forest and inland outcrops within a 250 m radius of the shoreline colonies were examined for additional colonies.

Results and Discussion

Distribution

Thirty-two colonies were reported from southeastern Manitoba between Indian Bay and Norway House (Table 1, Figure 2); hence the species is much more abundant in southeastern Manitoba than was indicated by the paucity of reports in the literature. The most northern colonies, at Rice River and Norway House, were not accessible to us but are considered valid because each is based on several individual reports. Most colonies are located in the Lower English River section of the Boreal Forest Region and all are located along the Rice, Winnipeg, Wanipigow/Manigotagan, and Lake of the Woods

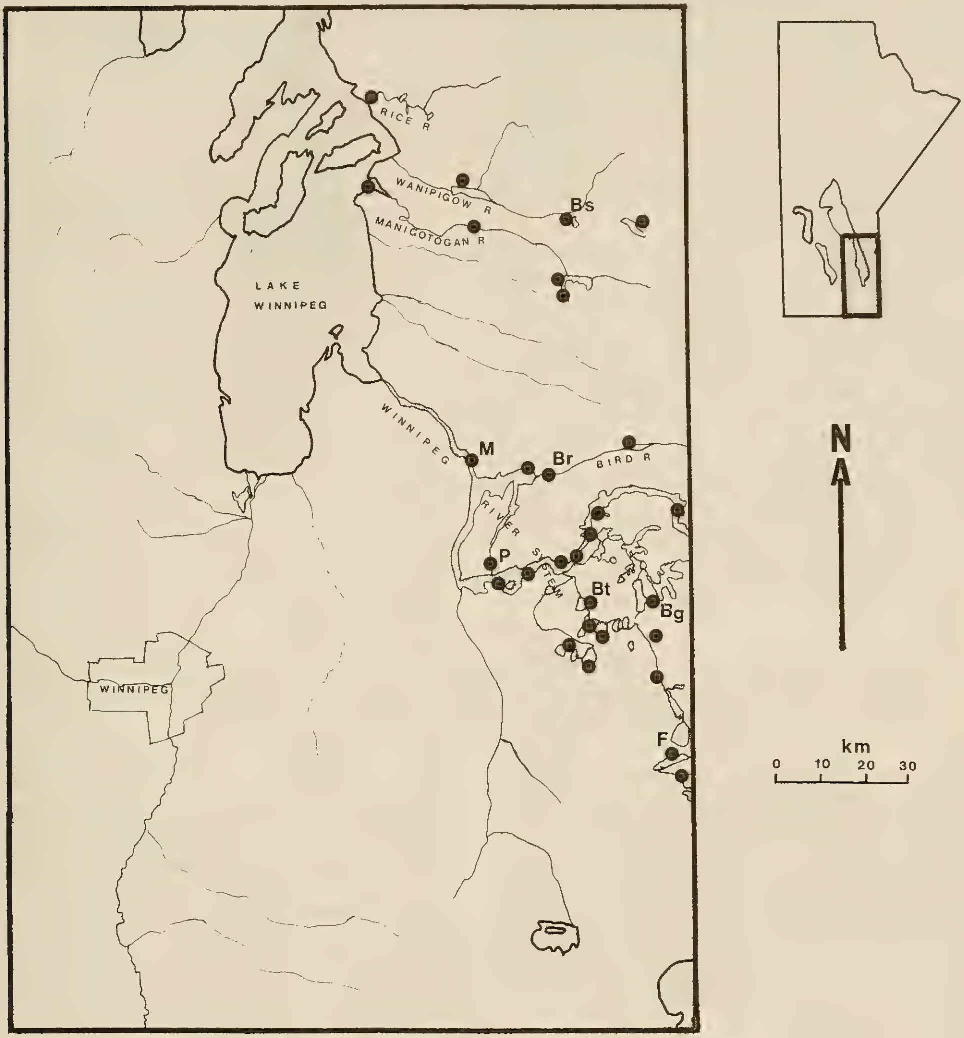

FIGURE 2. Colonies of *Opuntia fragilis* reported in southeastern Manitoba. Seven colonies studied in detail: Bissett (Bs), Bird River (Br), MacArthur Falls (M), Pinawa (P), Big Whiteshell (Bg), Betula Lake (Bt), and Falcon Lake (F).

river systems. Curiously, there are no reports from adjacent rivers which pass through the same habitats (e.g. Beaver Creek, Black River). This may be due to the relatively low human population density and absence of tourism along these rivers.

The Canadian distribution (Figure 3) extends from coastal British Columbia to Lake of the Woods, Ontario, and north to the Peace River district in British Columbia and Alberta. The colonies in southeastern Manitoba represent the extreme northeast of this range. The colonies reported from "islands and shores of Rainy Lake and Lake of the Woods, Ontario" (Scoggan 1979) are likely contiguous with those in southeastern Manitoba, and similarly are likely to be more numerous than is currently realized.

Abundance

The arrangement and size of cactus colonies (Table 1) ranged from three discrete clumps with a total of 354 pads (MacArthur Falls) to over 50 clumps with a total of about 8000 pads (Big Whiteshell). (The latter site has been declared a "special area" by the Provincial government for its botanical value.) Six of

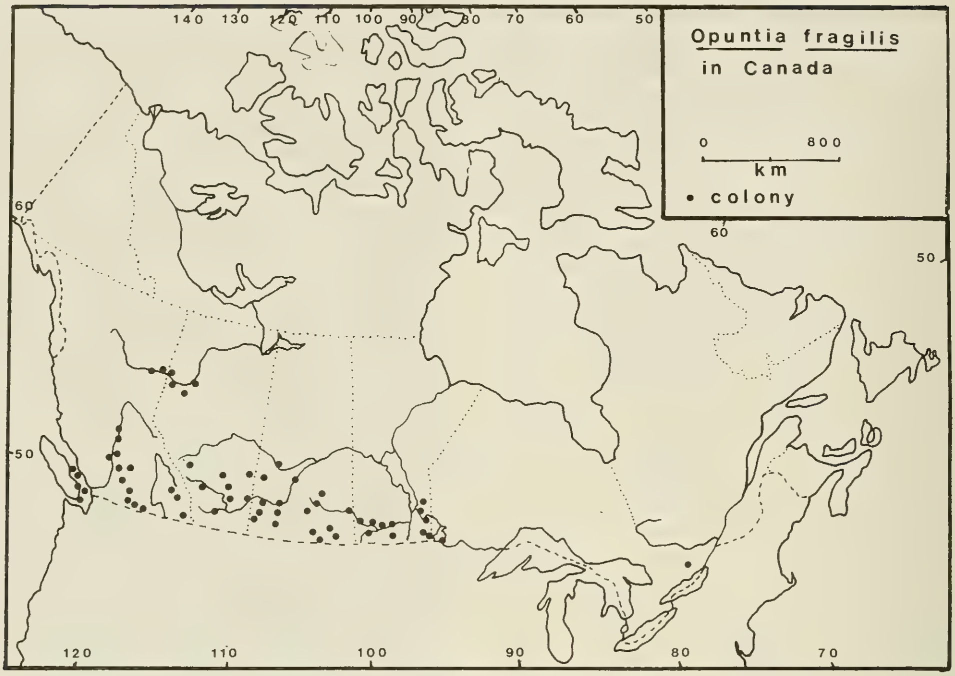

FIGURE 3. Distribution of *Opuntia fragilis* in Canada, from UWIN, UWPG, MMMN, DAO, WNRE, CAN, UBC, USAS, UVIC, V, ALTA, LEA, UAC, SASK, and SCS.

the seven colonies examined contained more than 100 pads each. Colony dimensions, pad numbers, and the number of clumps per outcrop were not correlated (α =0.05) with any of the soil variables measured (i.e. macronutrient content, organic content, pH, bulk density or conductivity). On the basis of colony and pad numbers, we feel that White and Johnson (1980) are justified in excluding this species from the rare and endangered species list for Manitoba.

Habitat

All colonies occurred on sloping (rarely, horizontal) south-facing rock outcrops between 0.9 and 15.0 m above and from 10.5 and 32.0 m away from the shores of rivers and lakes. Exposed rocks are often heated several degrees above the temperature of the surrounding substrate by radiant energy and they have the capacity to retain heat for longer periods of time (Rejmanek 1971). These effects would be increased by the southern exposure of the Prickly-pear sites which would therefore experience early spring snow melt, heat retention during cool spring and autumn nights, and extended growing seasons. Brittle Prickly-pear colonies were absent from rock outcrops away from the water's edge, even though these outcrops appeared similar and were often less than 50 m away from riparian outcrops with colonies. It is unlikely that the species has dispersal limitations which would account for this distribution because the dispersal units (pads) are dispersed by animals as well as by flotation (Frego and Staniforth 1985), and hence have a means of transport away from riparian sites. Two other theories may account for the absence of the species on inland outcrops. Firstly, fires may have eliminated the cacti from non-riparian sites which presumably would be less protected than those on the shorelines. Secondly, inland outcrops are shaded by adjacent forest during periods when the sun's angle is low (morning, evening, spring, autumn), with the result that the growing season is shortened and light intensity reduced at such sites.

Vegetation on outcrops consisted of isolated patches of dense plant cover, each patch being associated with a crack or depression in the rock surface (Frego and Staniforth 1986). The smallest quadrat size (0.09 m^2) centred on the prickly-pear colonies had the highest average plant cover values. The larger quadrats (1.0 and 16.0 m^2) extended on to sparsely colonized rock surfaces adjacent to the vegetation patches. Consequently, they had lower cover values. These data indicated that most patches of vegetation containing prickly-pears were less than 1.0 m wide and that these patches were surrounded by areas of low vegetation cover.

TABLE 1. Physiographic characteristics of seven Brittle Prickly-pear Cactus study sites, and colony dimensions.

Site	River	Outcrop size (m^2)	Mean Slope	No. of clumps of cacti on outcrop	Approx. no. of pads on outcrop	Maximum distance from water (m)	
						horizontal	vertical
Falcon Lake 49°43'N, 95°15'W	Lake of the Woods	72	1:6.5	10–15	5000	10.5	0.9
Big Whiteshell Lake 50°06'N, 95°20'W	Whiteshell River	184	1:6.7	50+	8000	20.0	3.0
Betula Lake 50°05'N, 95°35'W	Whiteshell River	36*	1:2	10–15	1000+	30.0	15.0
Pinawa Channel 50°09'N, 95°53'W	Winnipeg River	125	1:7	16	1300+	18.5	2.5
Bird River 50°25'N, 95°41'W	Winnipeg River	120	1:2	31	3000+	20.0	7.0
MacArthur Falls 50°24'N, 96°00'W	Winnipeg River	270	1:11	3	354	22.0	2.0
Rice Lake, Bissett 51°02'N, 95°41'W	Wanipigow River	450	1:3.7	20	4000	30.0	8.0

*Represents area of ledges on which cacti were found. The entire outcrop covered approximately 5 km^2.

Forty-six plant taxa were recorded along with the prickly-pear colonies in the outcrop survey (Table 2A). Of these, only aspen (*Populus tremuloides*) and Chokecherry (*Prunus virginiana*) were found in at least six of the seven sites. Other grassland species occurred on the outcrops with the Brittle Prickly-pear, e.g. Big Bluestem (*Andropogon gerardii*), Pink-flowered Onion (*Allium stellatum*), Douglas Knotweed (*Polygonum douglasii*), Prairie Lily (*Lilium philadelphicum*), and Alum Root (*Heuchera richardsonii*).

The soils were extremely variable between sites (Table 2B), but all were organic ($\bar{x} = 46.7\%$) with low pH ($\bar{x} = 4.8$) and bulk density ($\bar{x} = 0.37$ g mL^{-1}). Available phosphorous, potassium and sulphate levels were low. Available nitrate was not measured as it may have been altered by freezing (Seifert 1964). The high organic content of the soils would aid in water retention, although their shallowness counteracted this effect and the substrates were very dry for long periods. Most cactus colonies were rooted in mats of mosses, especially *Tortula ruralis*, which are likely to have ameliorated the drying to some extent.

Possible Origins

Three hypotheses (Figure 4) are presented to explain the peculiar distribution of *O. fragilis* in southeastern Manitoba.

Flotation across glacial Lake Agassiz (11 000–8000 years B.P.). Grassland, which had become established south and west of Lake Agassiz between 11 000 and 8000 years ago (Ritchie 1969; Teller and Clayton 1983), may have been dispersed across Lake Agassiz and may have been deposited on the sides of spillways, deposition sites, and exposed land around the glacial lake. This hypothesis is supported by the present distribution of cacti, which is restricted to the lake outlets (cf. Zoltai 1967; Teller and Thorleifson 1983), e.g. the Red River spillway in North Dakota, Rainy River, Lake of the Woods, and even Kaladar, Ontario and deposition sites, e.g. the Assiniboine Delta at Spruce Woods Provincial Park (Figure 3A). This theory assumes that the cacti would have been carried in the direction of drainage (i.e. south, then east, and finally northeast as the lake level dropped (Zoltai 1967). The ability of pads to float for long periods (Frego and Staniforth 1985) and the occurrence of cacti above present water levels (e.g. Pinawa, Betula Lake) are also supportive of this theory. This theory does not account for the presence of other species with western affinities which are not known to be particularly water dispersed, e.g. Big Bluestem grass, Pink-flowered Onion.

Relicts of former widespread grasslands (8000-4500 years B.P.). During the warm, dry Altithermal Period (cf. Last and Teller 1983), grasslands were more

TABLE 2. Characteristics of outcrop sites (n = 14). (A) Vegetation. Values are mean percent cover in 1.0 m^2 quadrats, + = trace, — = present on outcrop but absent from quadrats. Nomenclature follows Scoggan (1979) for vascular plants, Crum (1976) for mosses. (B) Soils. Values are means ± 1 SD.

A. Vegetation — total cover	66.1		
Thallophyte — total	25.0	Geophyte — total	+
Grey crustose lichens	1.6	*Allium stellatum*	+
Foliose lichens	14.3	*Apocynum androsaemifolium*	+
Fruticose lichens	8.8	*Lilium philadelphicum*	+
Bryum pseudotriquetrum	+		
Grimmia apocarpa	0.7	Chamaephyte — total	24.9
Hedwigia ciliata	+	*Juniperus communis*	+
Polytrichum juniperinum	0.8	*J. horizontalis*	+
P. piliferum	0.4	*Opuntia fragilis*	18.9
Thuidium abietinum	0.8	*Prunus pumila*	1.4
Tortula ruralis	7.6	*Ribes oxyacanthoides*	2.1
		Rosa spp.	2.5
Therophyte — total	3.9	*Rubus idaeus*	+
Collinsia parviflora	–	*Selaginella rupestris*	—
Collomia linearis	—		
Geranium bicknellii	1.4	Phanerophyte — total	1.0
Panicum capillare	+	*Amelanchier alnifolia*	+
Polygonum convolvulus	2.5	*Populus tremuloides*	+
Portulaca oleracea	—	*Prunus pensylvanica*	+
Silene noctiflora	+	*P. virginiana*	+
		Quercus macrocarpa	+
Hemicryptophyte — total	1.3	*Rhus glabra*	+
Achillea millefolium	0.7	*Symphoricarpos albus*	+
Agrostis sp.	0.6	*Viburnum rafinesquianum*	+
Andropogon gerardii	—		
Campanula rotundifolia	+		
Carex spp.	—		
Corydalis sempervirens	+		
Heuchera richardsonii	—		
Houstonia longifolia	—		
Lithospermum canescens	—		
Saxifraga virginiensis	—		
Woodsia ilvensis	—		
B. Soil			
pH	4.8 ± 0.6	Conductivity	0.15 ± 0.09 mmhos/cm
Organic matter	46.7 ± 12.5%	Bulk density	0.37 ± 0.06 g/ml
Available phosphorous	8.1 ± 1.6 kg/ha	Available potassium	102.2 ± 81.4 kg/ha
Sulfate	3.7 ± 3.8 kg/ha		

extensive than they are at present (Figure 3B). They occurred as far north as The Pas in northwestern Manitoba (Ritchie 1976) and north-eastward to the Winnipeg River (Buchner 1981). Relict Altithermal grassland communities may have become isolated when the coniferous forest spread southward in response to the cooler post-Altithermal climate which commenced 4500 years ago. This hypothesis is supported by the presence of such typical grassland species as *Andropogon gerardii, Agropyron trachycaulon*, and *Allium stellatum* at the cactus sites. It is also consistent with the restriction of these communities to well-drained, sunny, south-facing slopes. Both the dates and species agree with Love's (1959) proposed arrival of "western elements" in the region currently occupied by boreal forest in Manitoba.

This hypothesis does not account for the restriction of colonies to rivers and lakeshores, and their absence from similar inland outcrops. It also fails to explain the occurrence of cacti on the Manigotagan/Wanipigow River system, which is both north of the grassland extension, and part of a separate drainage system.

Dispersal by humans (4500 years B.P. to present). Present day distribution of cacti along major river

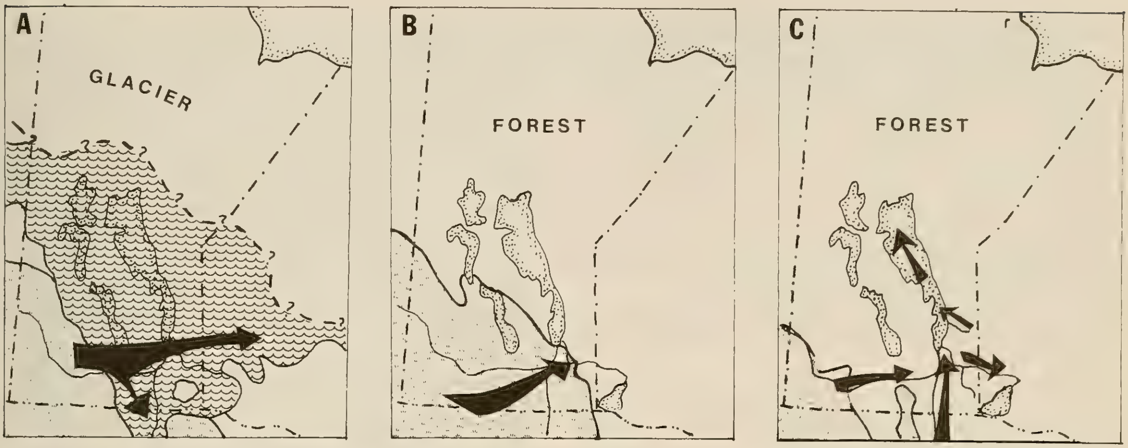

FIGURE 4. Three hypotheses concerning the arrival of Brittle Prickly-pear in southeastern Manitoba. (A) Flotation across Lake Agassiz, 11 000-8000 years. B.P. (B) Extension of grassland during Altithermal Period, 8000-4500 years. B.P. (C) Dispersal by humans along canoe routes, 4500 years. B.P. to present.

systems approximates the network of routes used by Indians and voyageurs between the prairies and trading centres east of Manitoba (Figure 3C). Colonies are especially common on rocks beside rapids, i.e. locations where portages were made. The cactus pads may have been carried on bales of fur and would have fallen off or have been picked off at sites of disembarkment. Alternatively, pads may have been purposely transported to such sites by Indians for food or technology. Szczawinski and Turner (1980) reported the use of boiled pads as a vegetable, pad mucilage for dye fixative, and spines for needles and fishhooks by Indian tribes in western Canada. Many of the colonies in southeastern Manitoba occur on historical camp sites. This hypothesis is further supported by the historical uses of other grassland species found in association with *O. fragilis* on riparian outcrops, e.g. *Allium stellatum, Heuchera richardsonii, Lithospermum canescens* (Densmore 1928; Szczawinski and Turner 1980; William Dore, personal communication). It also explains the occurrence of cacti far north of the known Altithermal grassland distribution, e.g. at Bissett and Rice River. Once established at riparian sites, it is unlikely that cacti could invade closed boreal communities, so their ranges remained restricted within this region.

Data are not available to allow the exact determination of the date of arrival of *Opuntia fragilis* in this region. It seems most likely that it is a relict of extensive grassland period during the Altithermal (8000-4500 B.P.) and that it has since been transported by flotation, or by humans along waterways, to more northern sites. In view of its absence from landlocked sites, it is probable that the distribution of the Brittle Prickly-pear Cactus has been maintained at a local level by flotation and/or human dispersal in southeastern Manitoba.

Conclusions

1. *Opuntia fragilis* is locally common on south-facing rock outcrops on the shores of waterways in the boreal forest of southeastern Manitoba.

2. These outcrop habitats are warmer and more xeric than the surrounding forest, with shallow, acidic, discontinuous soils of high organic content.

3. Brittle Prickly-pear Cactus, and other species of western affinities (cf. Love 1959), may have arrived in southeastern Manitoba during the Altithermal Period (8000-4500 years B.P.). Their presence north of the historical grassland extension (e.g. at Bissett, Rice River and Norway House) may be due to more recent human dispersal.

4. The present distribution of *O. fragilis* appears to be maintained by effective vegetative reproduction using stem fragments (pads), and by local dispersal by flotation and/or human activity along canoe routes.

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The Distinct Morphology and Germination of the Grains of Two Species of Wild Rice (*Zizania*, Poaceae)

S. G. AIKEN

Botany Division, National Museum of Natural Sciences, Ottawa K1A 0M8

Aiken, S. G. 1986. The distinct morphology and germination of the grains of two species of wild rice (*Zizania*, Poaceae). Canadian Field-Naturalist 100(2): 237–240.

Grain morphology alone can be used to distinguish the two species of annual wild rice, *Zizania aquatica* and *Z. palustris*. Their sequence of development during germination differs from that of most other grasses.

Key Words: *Zizania*, Poaceae, wild rice, germination, epiblast.

Current research has indicated that it is possible, with only a single grain, to identify the annual taxa of wild rice to species level. This is particularly relevant early in the growing season when it is easy to uproot a developing seedling with the grain attached, and identify it as either *Zizania aquatica* L. or *Z. palustris* L. — distinct from young *Vallisneria*, or *Sparganium* species that look similar.

Grain morphology

Fassett (1924) described morphological characters of the grains of annual wild rice to distinguish between the varieties of *Zizania aquatica* that he recognized (separating varieties *aquatica* L. and *brevis* Fassett, from *angustifolia* Hitchcock and *interior* Fassett). Dore (1969) photographed groups of ripe grains of *Z. aquatica* and *Z. palustris*, the two species that he recognized, but used other morphological characters to distinguish taxa. Dore and McNeill (1980) presented characteristics of the grains and spikelets as a major way to distinguish two species. There is an unfortunate mistake in the keys presented in Dore and McNeill (1980) in that the word "staminate" appears in place of the word "sterile". The distinction intended by W. G. Dore (personal communication) is that the spikelet bracts of *Z. aquatica* are thin-textured and when a grain fails to enlarge within them, they remain crimped and less than 1.5 mm wide (Figure 1b). The surface of the flowering bracts have sparse, minute, siliceous trichomes all over (Figures 1a; 2, left) and the ripe grains tend to cling to your hands and clothing. The bracts of *Z. palustris* are quite rigid, develop to their full size at flowering time and remain almost the same width, 1.5–2.0 mm, whether the caryopsis develops or not (Figure 1d). Trichomes on the flowering bracts of *Z. palustris* are limited to the apex and along the veins, usually more towards the apex (Figures 1c; 2, right).

W. G. Dore (personal communication) has stressed the size and position of trichomes on the larger floral bract, the lemma, as a useful taxonomic character. My observation is that the presence or absence of such trichomes on the mid-region of the palea is also characteristic and consistent in the two species. This feature is illustrated in Figure 2, which shows that the exposed surface of the palea of *Z. aquatica* (left) is sparsely covered with tiny siliceous trichomes, whereas the same surface of the palea of *Z. palustris* (right) is smooth.

Grain structure and germination.

In all annual taxa of wild rice, the grain is enclosed in the remains of the flowering spikelet with its two interlocking bracts. The grain consists of an elongated caryopsis (the ripened ovary characteristic of the grass family), and contains the seed with its embryonic plant as well as food reserves. The detailed structure of the caryopsis was described by Weir and Dale (1960). It is unusual in having a cotyledon that extends the entire length of the grain and an epiblast that is long and prominent (LaRue and Avery 1938).

Some features of the germination pattern of wild rice are here documented as unusual among grasses. These are (1) that the shoot appears before the root, and (2) that the epiblast emerges from the caryopsis. In all taxa of *Z. aquatica* and *Z. palustris*, the first evidence of sprouting is the appearance of a white slit in the lemma of an otherwise dark grain. Embryo enlargement splits the relatively thin, brown caryopsis wall and then the lemma along tissue adjacent to the midvein, exposing white epiblast tissue. In explaining the structure of a caryopsis, the epiblast has been variously interpreted, often as a cotyledon, or as part of one (Cutter 1971). In wild rice, the epiblast is one quarter to one third as long as the whole caryopsis and up to 1 mm wide at the base. It emerges first (Figure 3a) followed by the coleoptile (Figure 3b). At this stage, the epiblast appears swollen and fleshy; it may function to absorb water and convey it to the developing embryo. At the very least, the way in which

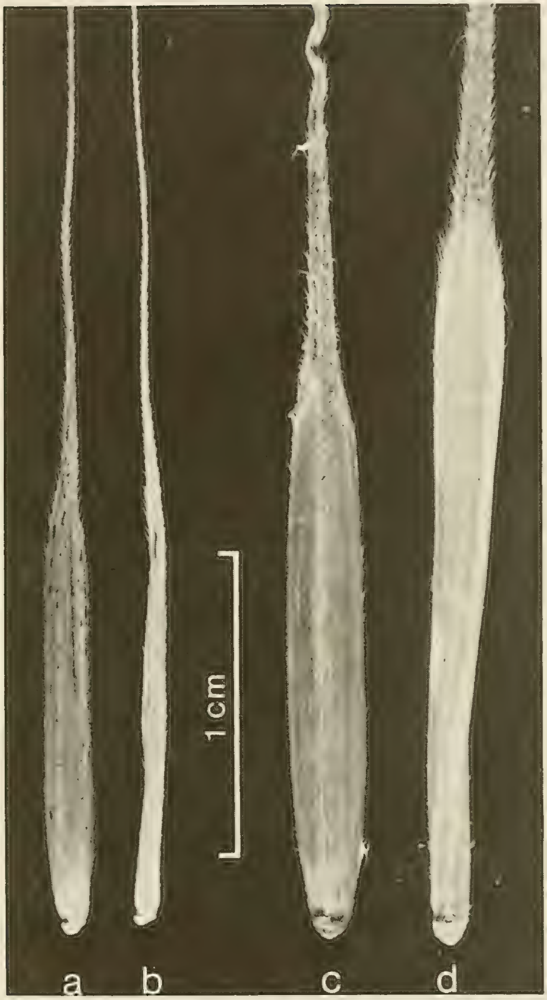

FIGURE 1. A comparison of the lemma surfaces of *Z. aquatica* (a,b) and *Z. palustris* (c,d); fertilized spikelets (a and c), sterile spikelets (b and d).

the epiblast curves away from the grain allows water easy access to soak into the inner portions of the caryopsis.

Figure 3b shows the epiblast that in Figure 3a was lying on the elongating coleoptile. Only after the coleoptile is well established (Figure 3c) does the primary root begin to emerge by penetrating the lemma towards the base of the grain where it was attached to the parent plant. Figure 3c shows the emerging root, the epiblast, and the elongating first internode with a bulge that is the first stem node, towards the top of the picture. Above the first node is the sheath of the first leaf.

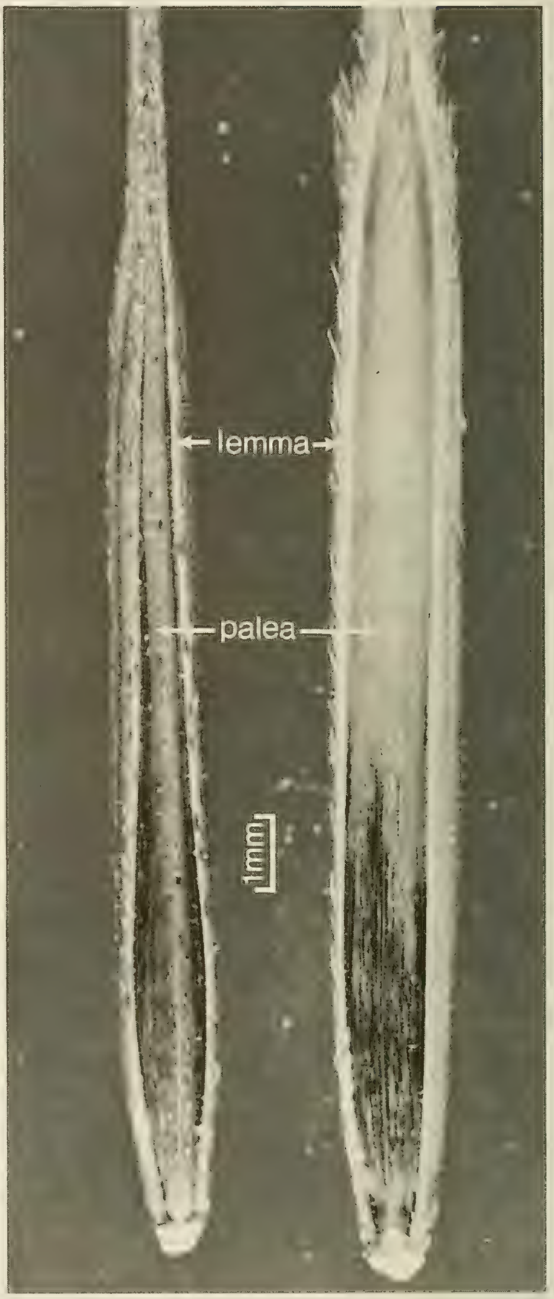

FIGURE 2. A comparison of the exposed palea surfaces of (left) *Z. aquatica* with minute trichomes and (right) *Z. palustris* with a glabrous surface.

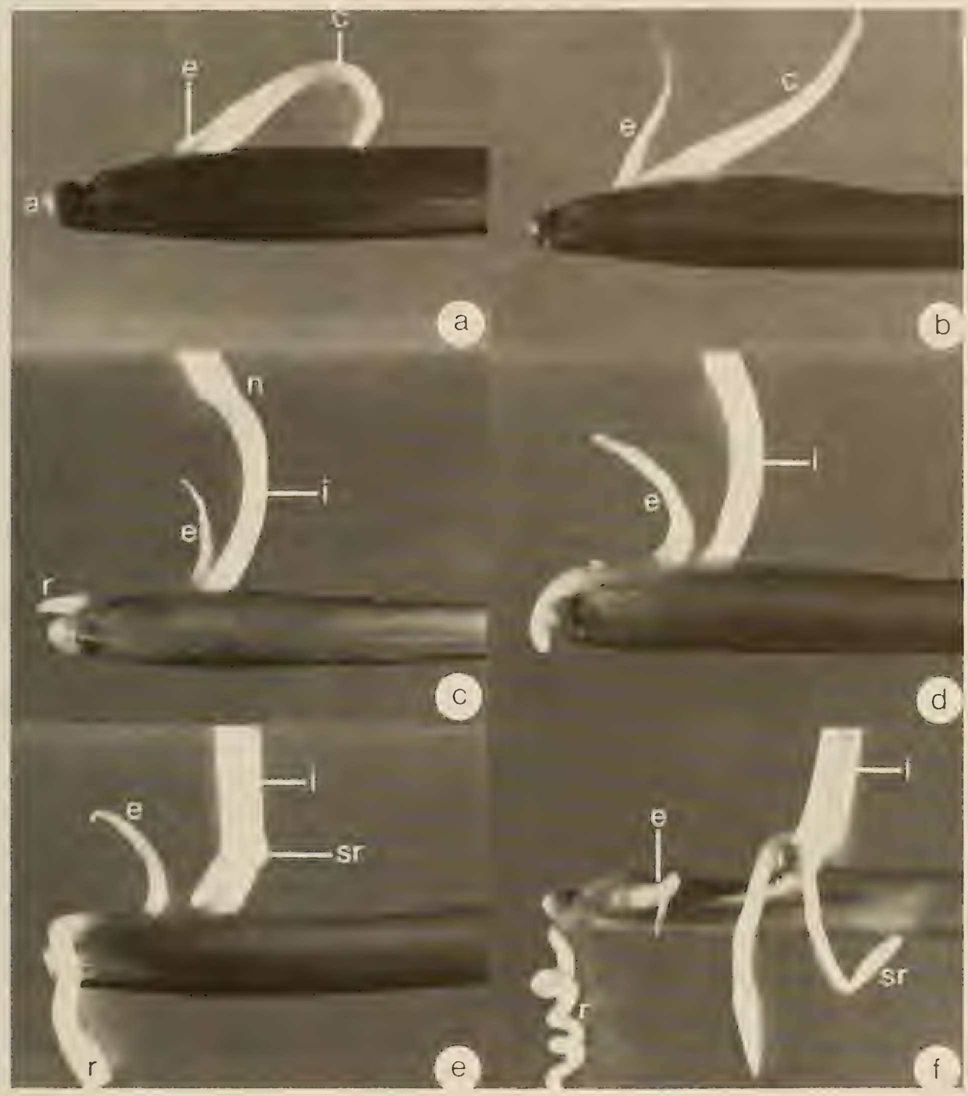

FIGURE 3. Stages in the germination of *Z. palustris* caryopses: a = point of attachment of grain, c = cotyledon, e = epiblast, i = internode, n = node, r = root, sr = secondary root.
(a) The caryopsis wall and lemma have split; the cotyledon is curled as it emerges from the grain; the epiblast is lying on the coleoptile. (b) The coleoptile has emerged from the grain and the epiblast has separated from the cotyledon. (c) The shoot below the cotyledon has elongated, exposing the first node and internode. The shoot is 2-3 cm long when the first root emerges and (d) curls towards the substrate. (e) Soon after the primary root is established, secondary roots begin to develop. (f) As secondary roots develop the epiblast shrinks and withers.

The grains photographed were germinated in about 7 mm of tap water in a petri dish; the first internode that developed was less than 5 mm long. The portion of the lemma between the epiblast and the first root remained intact (Figure 3d). At an early stage, secondary roots began to develop from the first internode (Figure 3e). These eventually replaced the primary root, as is characteristic of many grasses. The curling of the primary root (Figure 3f) is attributed to the germination of the grains in a petri dish, since it

has not been observed in seedlings from natural habitats. In Figure 3f the epiblast is shrunken, suggesting that, if it assumed some root functions earlier, these ceased with the establishment of the root system.

The photographs in Figure 3 are of different grains of *Z. palustris*, but all are magnified approximately 3.5X. The same germination pattern was observed for all annual wild rice taxa, in an isoenzyme experiment that involved growing more than 3000 seedlings (Warwick and Aiken 1985).

Bayly (1983) regarded the caryopsis, with its associated bracts, as a support organ for germinating wild rice. In the figure that accompanies her note, the seedling illustrated has a first internode (mesocotyl) more than 60 mm long, which is unusually long, even for wild rice. Oelke et al. (1982) claimed that a "wild rice seedling can emerge through 3 inches of flooded soil because the first internode can elongate up to 2 inches" (50 mm). Thus, the length of the first internode in wild rice may vary from a few millimeters (Figures 3e,f) to 60 mm.

In almost all seed plants, including grasses, the root emerges from the seed first. This has been presumed to indicate that the primary needs of the developing embryo are support from the root acting as an anchor, and water to mobilize food reserves. In wild rice, water in the environment is not a problem once the grain walls have split, and the emergence of the epiblast from the grain also assists in the early uptake of water by the embryo. The grain structure (Bayly 1983) along with the buoyancy of the water environment provide support for the early stages of development. However, the seedling shoot may have to grow between 50 and 100 cm before reaching sufficient sunlight for photosynthesis to replace food reserves, and this may explain why it emerges first.

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Seasonal Diets of Vancouver Island Marmots, *Marmota vancouverensis*

ARTHUR M. MARTELL[1] and ROBERT J. MILKO[2]

[1]Canadian Wildlife Service, Environment Canada, P.O. Box 340, Delta, British Columbia V4K 3Y3
[2]Department of Biology, University of Victoria, Victoria, British Columbia V8W 2Y2

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The diet of Vancouver Island Marmots (*Marmota vancouverensis*) was examined by fecal analysis at three subalpine colonies on four occasions between late May and mid-September. Two additional, high-elevation colonies were examined in late May only. Diets were similar among colonies but showed strong seasonal shifts. Diets were more variable among sites in late May than later in the summer, possibly reflecting site-specific availability at a time when food supply is limited. In late May *Phlox diffusa* and *Carex* sp. were important at all colonies but *Danthonia intermedia, Lupinus latifolius*, and sedge glumes were dominant at specific colonies. Later in the summer *Lupinus* and *Eriophyllum lanatum* were the major foods at all colonies. As summer progresssed the proportion of graminoids in the diet declined and the proportion of forbs increased. Vancouver Island Marmots in the subalpine appear to specialize on relatively few food species.

Key Words: Vancouver Island Marmot, *Marmota vancouverensis*, food habits, diets, fecal analysis, British Columbia.

The endemic Vancouver Island Marmot, *Marmota vancouverensis*, is most closely related to the Hoary Marmot, *M. caligata*, and the Olympic Marmot, *M. olympus* (Hoffmann et al. 1979). The Vancouver Island Marmot lives principally in a limited number of small colonies in subalpine habitats characterized by steep cliffs, talus, and open meadows (Heard 1977; Milko 1984). However, marmots, particularly young of the year, are also found in areas of logging slash (W. T. Munro, D. W. Janz, V. Heinsalu and G. W. Smith. 1983. Status and management of the Vancouver Island Marmot. Unpublished report. Fish and Wildlife Branch, Ministry of Environment, Victoria, British Columbia). Marmots emerge from hibernation in May when their habitat is often snow-covered and food is restricted, and return to hibernation in September (Heard 1977; Milko 1984).

The Vancouver Island Marmot is the rarest species of marmot in North America and is considered endangered by the Committee on the Status of Endangered Wildlife in Canada (W. T. Munro. 1979. Vancouver Island Marmot (*Marmota vancouverensis*). Unpublished report. Committee on the Status of Endangered Wildlife in Canada, Ottawa, Ontario) and by the Government of British Columbia (Munro et al. *op. cit.*). Because of the small number of marmots and the presence of unoccupied habitat, the Government of British Columbia is considering, as part of a long range management plan, the feasibility of transplanting marmots to new sites and enhancing other sites which may no longer be attractive to marmots (Munro et al. *ibid.*). A thorough knowledge of marmot food habits would contribute to the success of those proposals. The only data available, however, are visual observations (Heard 1977; Milko 1984). Therefore, the present study was initiated by the Canadian Wildlife Service, in cooperation with the University of Victoria, to examine seasonal and site variation in the diets of Vancouver Island Marmots.

Methods

Three colonies were chosen for study: Haley Lake (49°00′N, 124°18′W), Bell Creek (49°00′N, 124°19′W), and Butler Peak (49°00′N, 124°19′W). The Haley Lake and Bell Creek colonies are at 1150 m elevation and are likely part of the same population. The Butler Peak colony is at 1250 m elevation and is part of a second population. Fresh fecal material was collected at each of these colonies three times between late June and mid-September 1981. Because of problems with access to the colonies in 1981, the spring (late May) collection was not made until 1982. A second collection was made in late June 1982 for comparison with the 1981 samples. In addition, two high elevation (1450 m) colonies were sampled in spring 1982: Gemini Peak (49°02′N, 124°19′W) and Green Mountain (49°03′N, 124°20′W). Although the Gemini Peak colony has been considered to be part of the Haley Lake – Bell Creek population (Munro et al. *op.cit.*), it appears distinct from the other colonies in that population. The Green Mountain colony is part of a third population. No collections were made from marmots inhabiting slash areas where foods may differ from those in subalpine sites.

Four samples were collected at each colony at each sampling period. Each sample was composed of fecal material from 25 separate "fresh" droppings (Hansen 1975). Each sample was homogenized in a blender and

preserved with salt. Analysis of the fecal samples (Sparks and Malechek 1968) was conducted at the Composition Analysis Laboratory at Colorado State University, Fort Collins. The relative density of plant fragments was based on 100 fields per sample. All samples were analysed at the same time by the same technician. Samples of 116 species of plants collected in Vancouver Island Marmot habitat were provided to assist with the identification of plant fragments.

Because the results of the analyses are presented as proportions of unknown and unequal numbers of identified fragments per sample, parametric tests could not be used. Diet similarity among colonies and dates was evaluated using percent similarity (Pielou 1975) as an index. Differences in major food items among the three principal colonies and among the five dates that they were sampled were examined using a Friedman two-way analysis of variance (Siegal 1956). The significance of differences between mean ranks was tested using a distribution-free multiple comparison procedure based on Friedman rank sums (Hollander and Wolfe 1973).

Results

The average percent similarity in diet among the Haley Lake, Bell Creek, and Butler Peak colonies was lowest in late May (18%), had increased by late June (59%), and was high in early August (79%) and mid-September (77%). The two high-elevation colonies (Gemini and Green mountains) were more similar to each other in late May (45%) than they were to the lower elevation colonies (34%). Considering all dates, Haley Lake and Bell Creek were the most similar to each other (62%) but Butler Peak was also quite similar to both Haley Lake (54%) and Bell Creek (59%).

The average similarity in diet was generally much lower during summer (Haley Lake, 32%; Bell Creek, 58%; Butler Peak, 35%) than among colonies. However, the two late June samples showed a high similarity (67%) between years.

Eight food classes (mosses, mycorrhiza, lichens, ferns, gymnosperms, grasses, graminoids, forbs) and the 12 most consistently used foods (*Cetraria, Chaemacyparis nootkatensis-Juniperus communis, Tsuga* sp., *Danthonia intermedia, Poa* sp., *Carex* sp., *Luzula* sp., *Achillea millefolium, Eriophyllum lanatum, Lathyrus nevadensis, Lupinus latifolius*, and *Phlox diffusa*) were tested for site and seasonal differences. There were only four significant differences among sites. Marmots at the Bell Creek colony consumed significantly less *Danthonia* ($p < 0.05$) and monocots ($p < 0.05$) than those at the Butler Peak colony, but they ate significantly more *Poa* ($p < 0.05$) and fern ($p < 0.01$) than those at Butler Peak. However, both *Poa* and fern were relatively unimportant in the diet of marmots at any colony.

Because seasonal differences were more consistent and greater than site differences, the three principal colonies were combined for presentation (Table 1). Also, the two late June samples were combined because of the high degree of similarity and absence of significant differences between years. The results from the two high-elevation colonies in late May are presented separately for comparison (Table 1).

Although many of the foods showed seasonal trends, only two species showed significant differences among dates. The proportion of *Danthonia* in the diet decreased over summer and the proportion in mid-September was significantly less than that in late May ($p < 0.05$). In contrast, the proportion of *Eriophyllum* in the diet increased over summer and the proportion in mid-September was significantly greater than that in late May ($p < 0.05$). Both *Danthonia* and *Eriophyllum* were important components of the diet.

The greatest difference among colonies in diet was expressed in late May. *Phlox* and *Carex* were important at all three colonies. Sedge glumes were particularly important at Haley Lake, *Lupinus* at Bell Creek, and *Danthonia* at Butler Peak. *Danthonia, Phlox*, and *Carex* were the principal foods at the two high-elevation colonies. Late June food habits were more similar among colonies, with *Lupinus* and *Carex* being major foods at the three lower elevation colonies. However, other important foods were *Eriophyllum* at Haley Lake, *Lathyrus* at Bell Creek, and *Luzula* at Butler Peak. By early August *Lupinus* and *Eriophyllum* made up over 78% of the diet at all three lower elevation colonies. These two foods increased in importance by mid-September, but *Eriophyllum* predominated in September, whereas *Lupinus* predominated in August.

Discussion

Holechek et al. (1982) reviewed the procedures used for estimating the botanical composition of the diet of wild herbivores and concluded that fecal analysis, despite its limitations, is the method of choice in many situations because it gives good sampling precision and does not require animal sacrifice. The only other method available to us — direct observation — is hampered by visibility of the marmots and food species identification and quantification. However, we do not mean to minimize the disadvantages of fecal analysis. The main disadvantage is lack of accuracy because of differential digestion among plant species (Holechek et al. 1982). Poorly digested or easily fragmented species tend to be overestimated while

TABLE 1. Average percentages (± SE) of discerned plant fragments in fecal samples collected from Vancouver Island Marmots (*Marmota vancouverensis*). Sample sizes in parentheses.

	Green Mt. — Gemini Peak	Haley Lake — Bell Creek — Butler Peak			
Food Items[1]	82.05.25 (8)	82.05.19 - 82.06.04 (12)	81.06.24-25 82.06.20-30 (24)	81.08.06-07 (12)	81.09.14 (12)
Moss	—	1.2 ± 0.29	0.2 ± 0.08	tr[2]	0.1 ± 0.07
Mycorrhiza	—	0.5 ± 0.31	3.2 ± 1.48	0.2 ± 0.12	—
Lichens	1.6 ± 0.35	0.4 ± 0.11	0.4 ± 0.12	tr	tr
Cladonia — type	1.2 ± 0.24	0.1 ± 0.10	0.2 ± 0.08	—	—
Ferns	0.1 ± 0.10	2.6 ± 0.95	1.1 ± 0.45	0.3 ± 0.16	1.0 ± 0.33
Gymnosperms	3.2 ± 1.48	3.6 ± 1.38	0.9 ± 0.28	0.4 ± 0.21	0.4 ± 0.15
Chaemacyparis nootkatensis (= *Juniperus communis*)	3.2 ± 1.48	1.4 ± 0.58	0.6 ± 0.20	0.1 ± 0.14	0.3 ± 0.11
Tsuga sp.	—	2.2 ± 0.97	0.2 ± 0.09	0.2 ± 0.18	0.1 ± 0.07
Graminoids	54.9 ± 5.16	56.4 ± 8.76	24.1 ± 4.61	3.7 ± 0.72	2.7 ± 0.97
Danthonia intermedia	30.8 ± 9.92	18.7 ± 6.97	1.3 ± 0.28	0.5 ± 0.12	0.3 ± 0.13
Festuca sp.	0.9 ± 0.56	tr	tr	—	—
Poa sp.	0.9 ± 0.37	0.5 ± 0.18	0.7 ± 0.15	0.2 ± 0.12	tr
Carex sp.	21.6 ± 6.97	8.8 ± 1.05	16.2 ± 3.02	1.9 ± 0.47	0.8 ± 0.30
Luzula sp.	0.4 ± 0.16	1.1 ± 0.35	5.4 ± 1.72	1.0 ± 0.53	1.4 ± 0.85
Sedge glume	—	26.9 ± 11.23	tr	—	—
Forbs	40.1 ± 6.01	34.5 ± 6.54	68.3 ± 4.86	94.0 ± 1.17	93.4 ± 1.70
Archillea millefolium	0.1 ± 0.08	3.6 ± 2.70	2.1 ± 0.36	0.4 ± 0.20	1.5 ± 0.31
Castilleja sp.	—	—	0.6 ± 0.24	0.6 ± 0.23	—
Eriophyllum lanatum	0.3 ± 0.26	1.4 ± 1.20	7.8 ± 2.35	19.3 ± 6.78	63.1 ± 4.32
Lathyrus nevadensis	—	0.7 ± 0.54	8.6 ± 1.63	4.0 ± 1.82	tr
Lupinus latifolius	0.3 ± 0.11	16.8 ± 6.77	46.1 ± 3.56	68.5 ± 6.34	28.1 ± 3.21
Phlox diffusa	34.3 ± 6.48	14.0 ± 3.91	2.5 ± 0.64	0.3 ± 0.09	0.9 ± 0.24
Prunella vulgaris	4.7 ± 0.90	0.4 ± 0.04	tr	—	tr
Vaccinium sp. seeds	—	—	—	—	0.7 ± 0.53
Arthropods[3]	0.1 ± 0.10	—	1.7 ± 0.43	1.3 ± 0.43	1.0 ± 0.50

[1]*Abies lasiocarpa, Agrostis* sp., *Alectoria* sp., *Arceuthobium* sp., *Bromus sitchensis, Cetraria*-type lichens, *Elymus glaucus, Fragaria vesca, Phleum alpinum, Potentilla* sp., *Saxifraga* sp., *Sibbaldia procumbens, Vaccinium* sp., and *Viola* sp. occurred at average frequencies of less than 0.5% in some sampling periods.
[2]tr = < 0.1%
[3]Arthropods likely entered the fecal material after it was deposited rather than by direct ingestion.

easily digested species, such as flowers of forbs, tend to be underestimated or even missed. Frase (1982) found that forbs were seriously underestimated in the fecal analysis of the diet of Yellow-bellied Marmots (*M. flaviventris*) in Colorado. However, Carey (1983), working on Yellow-bellied Marmots in California, found that two forb species and one grass used in laboratory trials gave essentially a 1:1 relationship between relative fecal composition and relative dry weight in the diet. We were not able to run laboratory trials to assess accuracy; therefore, the results presented should be considered to represent the proportions of discerned plant fragments in fecal samples rather than actual proportions of the ingested diet. For convenience, however, we refer to our "estimate of the diet" as "diet".

We observed a greater difference in diet over the season than either between years or among colonies. Hansen (1973) compared the diets of Hoary Marmots in Alaska in mid-summer on three mountains during two years. Like us, he found the diet to be similar between years and among mountains. We found the differences between colonies to be most pronounced in spring. The higher elevation colonies were most similar to each other and they were most similar to the highest of the lower elevation sites. Food supply is most restricted in spring and marmots at each colony likely search for whatever is most available depending on snow melt and the amount of early plant growth. The high consumption of sedge glumes at one colony at this time may indicate consumption of overwintered seeds, while a high ingestion of *Lupinus* at another colony may indicate more advanced plant phenology. The predominance of *Danthonia* and

Phlox in the diet at the higher elevation sites likely represents the use of cliffs, which are free of snow earlier than the meadows below them. In general, the major spring foods indicated in the fecal analysis are consistent with those observed in use-availability studies (Milko 1984).

Later in the season, only a few foods make up the majority of the diet at all colonies. This suggests that these foods are either abundant at all sites or that they are essential to permit marmots to build up their fat reserves before hibernation. Two of the most prominent foods in late summer, *Lupinus* and *Eriophyllum*, are abundant at the colony sites, but whereas *Lupinus* was often seen being eaten, there are few observations of *Eriophyllum* being consumed (Heard 1977; Milko 1984). The cell fragments of *Eriophyllum* in fecal samples is similar to that of *Antennaria* and *Cirsium* but the material in our samples was closer to *Eriophyllum* (T. Foppe, personal communication. Composition Analysis Laboratory). However, *Antennaria* spp. are rare in the study area and *Cirsium edule*, while abundant, was also rarely seen being eaten by marmots (Heard 1977; Milko 1984). It is possible that *Eriophyllum* was either overestimated in the fecal analysis or that it was difficult to see being eaten. However, based on other evidence (Milko 1984) we strongly suggest that it was overestimated. The shift over summer from graminoids to forbs, also reflected in use-availability studies (Milko 1984), is important because it likely reflects the shift over summer in available biomass and food quality between these two groups (Carey 1983; Frase 1982). An examination of food selection by Vancouver Island Marmots (Milko 1984) indicated that although abundance may influence selection, there was no significant correlation between use and availability.

It is difficult to compare the diet of the Vancouver Island Marmot with that of other alpine and subalpine marmots because of the paucity of quantitative studies. Knowledge of the diet of the Olympic Marmot is based on visual observations (Barash 1973; Wood 1973). Like Vancouver Island Marmots, Olympic Marmots feed on grasses upon emerging from hibernation but shift to forbs, particularly the flowers, later in the summer. Both Barash (1973) and Wood (1973) note the importance of *Lupinus* to Olympic Marmots in mid to late summer. Although there are some visual observations of the foods of the Hoary Marmot in British Columbia (Gray 1967), the only quantitative studies are from Alaska (Hansen 1975; Holmes 1979). Holmes (1979), working in south-central Alaska, found the dominant food to be *Carex* and found little seasonal variation in diet between mid-June and mid-August. Hansen (1975), working farther south on the Kenai Peninsula, found forbs to be more important than graminoids in mid-summer. This likely reflects site-specific differences in diet. Recent studies of Yellow-bellied Marmots in Colorado (Frase 1982) and California (Carey 1983) show that graminoids decline and forbs increase in importance over summer, as we found for Vancouver Island Marmots.

We found that relatively few species made up the bulk of the diet and that these species were used at all sites. Marmots showed some flexibility in diet in spring, when site-specific availability may be important, but were more conservative in summer. That suggests that the availability of these major food species should be considered when planning transplants of marmots or habitat enhancement in subalpine areas.

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Distribution of Basking Sharks, *Cetorhinus maximus*, Incidentally Caught in Inshore Fishing Gear in Newfoundland*

JON LIEN and LEESA FAWCETT

Newfoundland Institute for Cold Ocean Science and Department of Psychology, Memorial University of Newfoundland, St. John's, Newfoundland A1C 3X9

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Between 1980-1983, 371 Basking sharks (*Cetorhinus maximus*) were incidentally caught in inshore fishing gear, primarily salmon gillnets and codtraps, in the coastal waters of Newfoundland. Yearly and seasonal variation in captures was related to seawater temperatures between 8-12°C. More males than females were captured; directed fisheries have found male/female ratios of 1:30-40. The different ratios which result from incidental and directed captures probably indicate that surface activity of males and females are different. Few immature sharks (2.6% of total catch) were reported.

Key Words: Basking Shark, *Cetorhinus maximus*, incidental fishing catches, sex ratio, Newfoundland.

Between 1977 and 1980, inshore fishermen in Newfoundland reported a substantial increase in the number of large whales they saw inshore and in the damage the animals produced as a result of collisions with fishing gear. In 1979 losses to inshore fishermen due to gear damage and fish losses represented 2–3% of the total value of the inshore fishery (Lien 1980). Although fishermen typically attributed this damage to whales, as we studied the collision problem it became clear, through sightings and incidental catches of Basking Sharks (*Cetorhinus maximus*), that this species commonly contributed to the problem. Damage to inshore fishing gear by Basking Sharks has been occasionally reported in inshore fisheries in other areas (Lien and Aldrich 1982). Basking Sharks have been associated with gear damage on the Pacific coast of Canada and, for a while, Department of Fisheries patrol vessels were equipped with sharpened projections on their prows with which to kill the sharks.

Templeman (1963) lists 61 Basking Sharks incidentally caught in Newfoundland from 1876-1962. Most of these were caught on the southwest coast from Port aux Basques to Burgeo in July, but catches on the northeast coast were also common. The incidental catch was historically more common than indicated by these reports, as oil from livers was frequently purchased by local fish companies (F. Earle, personal communication) and reports of incidental catches occur fairly regularly in local publications (Lien and Aldrich 1982). However, Templeman (1963) has been the only scientist to make a systematic effort to record Newfoundland distribution to date. Some information on the Atlantic distribution is presented by Gudger (1948), Bigelow and Schroeder (1948), and Springer and Gilbert (1976).

In 1980 we began monitoring the incidental catch of Basking Sharks in the coastal waters of Newfoundland. The present paper reports on the distribution of those incidentally caught in inshore waters off Newfoundland from 1980-1984 and on the results of a retrospective survey of catches from 1970-1980.

Methods

Monitoring incidental catches. In 1979 a reporting system for whale damage to fishing gear was organized. Report cards were extensively distributed to fishermen in all areas of Newfoundland and Labrador and a toll-free phone number was established which fishermen could call to report incidental catch. In 1980, advertising distributed to fishermen encouraged them to report large sharks as well as whales. The reporting system was extensively used. By comparing the reported catch by card and phone to the catch reported in onsite interviews, it was estimated that about 90% of incidentally caught Basking Sharks were reported (Lien 1980).

In 1981, a widely advertised market developed for Basking Shark fins and liver, and fishermen could sell incidentally-caught animals. This market continued in 1982. To obtain information about selling their sharks, fishermen called us. In 1981-1982 at least 90% of incidentally caught animals were reported. Markets were late in developing in 1983, and prices were low, so fishermen were not as willing to report. Comparing the reported catch to the catch based on interviews, it is unlikely that more than 75% of incidentally caught sharks were reported.

Sex, estimates of length, location of catch, and gear

characteristics were obtained from fishermen when a catch was reported. When possible we traveled to the site to examine and measure the animal (N = 67). Fork lengths reported were made as outlined by Bigelow and Schroeder (1949). Sea surface temperature data were obtained from the Canadian Forces Metoc Centre.

Retrospective survey of catch. To determine whether the incidental catch of Basking Sharks had increased recently, fishermen who had caught sharks in 1980 or 1981 were sent two copies of a questionnaire requesting information on their fishing effort and the number of sharks caught from 1970-1980. Of 124 fishermen that caught sharks in 1980-1981, 52% responded. They were directed to give the second copy of the survey to a neighbouring fishermen who did not catch a shark in 1980-1981, and 29 questionnaires from these control fishermen were returned. Presumably, fishermen that caught sharks and did not respond to the survey also did not give the questionnaire to a neighbour. Thus the maximum number of questionnaires distributed to fishermen that did not catch a shark in 1980-1981 was 65, of which the return rate was approximately 45%.

Results

From 1980-1983, 371 Basking Sharks were incidentally caught in Newfoundland's coastal waters. Considerable year-to-year variation was observed in the number of sharks caught: 1980 (66), 1981 (125), 1982 (35), and 1983 (145). Correcting reported catch results for estimated under-reporting produces a total of about 410 animals caught during this period.

Incidental catches were concentrated on the southwest coasts between Port aux Basques and Hermitage, although lesser concentrations occurred in other areas such as Conception Bay and Fogo Island (Figure 1). Most captures occurred near headlands rather than in bays.

Variation in the numbers and locations of captures was a function of seawater temperature (Table 1); 90% of the Basking Sharks were caught in surface temperatures between 8–12°C. Year to year variation in the catch was related to mean seawater temperature in major catch areas. The lowest mean surface temperature in major catch areas was 7.3°C in 1982 when only 35 sharks were taken. Intermediate mean surface temperatures occurred in 1980 and 1982. The highest catch occurred in 1983 (145 animals) when an average surface temperature of 9.3°C occurred. Warming of surface water varied between years. Catches rarely occurred until surface water warmed to 6°C; incidental catches were not common until surface water had warmed to 8°C. Most sharks were caught between mid-June and mid-July (Table 2).

Sharks were typically captured by fishing gear near the surface such as salmon gill nets (53%) and codtraps (27%). Occasionally the sharks were caught in ground fish gillnets (15%) which are operated in deeper water (60–600 m).

The first sharks caught each year were males on the southwest coast. Later captures in other locations were predominately female with occasional males (Figure 2). On average, females occurred in incidental catch reports seven days earlier than did males (Table 3). A total of 82 males (69.4%) and 36 females (30.6%) was examined. Males (7.5 m) were slightly larger than females (6.9 m) [N = 67] (Table 4).

Nine immature sharks, five males and four females, were reported captured. Each animal exhibited the pointed snout (Figure 3) described by Matthews and Parker (1950). Mean length was 3.0 m, with a range from 1.8–3.9 m. The median date of capture was 11 July, about two weeks later than the median adult date of capture. Immature captures occurred primarily in eastern Newfoundland (Figure 4).

Results of the survey requesting fishermen to retrospectively report the incidental Basking Shark catch are reported in Table 5. Fishing effort in the sample did not vary significantly from year to year; the number of sharks caught from 1970-1980 did not vary significantly. In 1981, significantly more sharks were caught ($p < 0.05$).

Discussion

The spatial and temporal pattern of the incidental catch of Basking Sharks from 1980-1983 was similar to Templeman's (1963) catch records from 1876-1962. Incidental catch occurs earliest and most commonly on the southwest coast from Port aux Basques to Hermitage. Catches on the northeast coast are also common but are more scattered and occur later in the summer.

Basking Sharks are believed to over-winter in deep water (Parker and Stott 1965). Occasional winter catch by trawlers fishing in the Gulf of St. Lawrence (Lien and Aldrich 1982) indicate that some Basking Sharks over-winter there. This deep water area is the closest to the Newfoundland inshore fishing area. Thus the earlier occurrence of Basking Sharks on the southwest coast may be explained by this combination of proximity to deepwater and the seasonal warming (to 8–12°C range by mid-June) of surface waters.

The temperature range for incidental catch (8–12°C) is narrow. Squire (1967) reports that Basking Sharks were least abundant in surface water over 14°C. Minimum surface temperatures found here are also similar to those reported from other areas (Maxwell 1952). The seasonal inshore

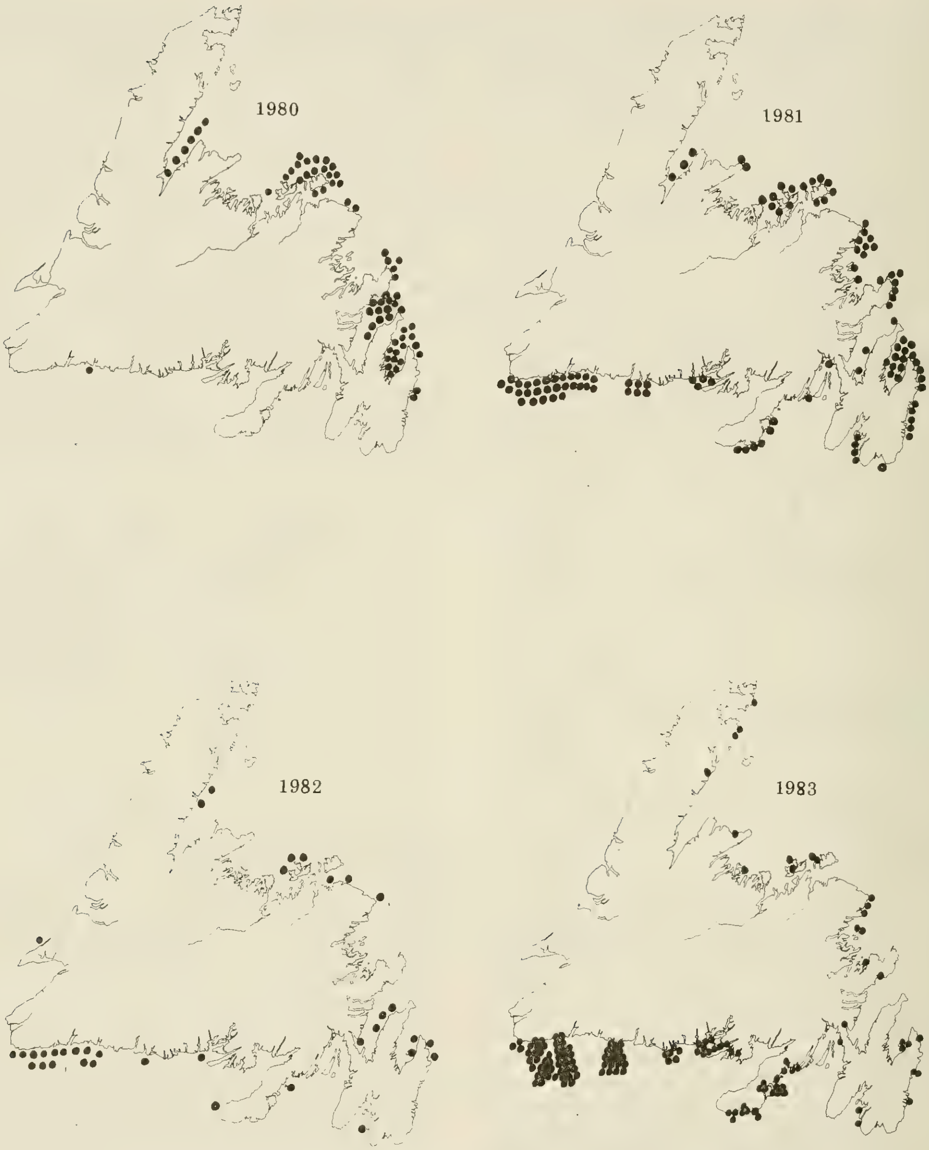

FIGURE 1. Incidentally caught Basking Sharks in Newfoundland (1980-1983).

excursions of Basking Sharks may be related to feeding (Hallacher 1977; Matthews 1950) and sexual activity (Matthews 1950, 1962). Higher surface water temperatures do generally coincide with high planktonic biomass in Newfoundland (Davies 1982), but the relationship is complex.

We were able to sex 34% of incidentally caught sharks between 1980-1983: 70% were male, 30% females. Matthews (1962) reported that females outnumber males by 30–40 to 1 in the commercial catch off the Hebrides and reports a similar ratio in the fishery off Scotland. Commercial fishing is based on sightings of animals and harpooning at the surface. Salmon nets and codtraps which catch Basking Sharks in Newfoundland are operated from the surface to a depth of 10–30 m. They would catch not

TABLE 1. Incidental inshore catch of Basking Sharks (1980-1983) and mean weekly surface temperature (2°C).

Temperature	Catch 1980	1981	1982	1983	Total	Percentage
2	0	0	0	0	0	0
4	0	0	0	1	1	0.3
6	3	8	0	5	16	4.7
8	16	47	16	57	135	39.5
10	20	35	5	28	88	25.7
12	12	12	11	50	85	24.9
14	0	5	3	5	13	3.8
16	0	4	0	0	4	1.2
18	0	0	0	0	0	0

TABLE 2. Dates of verified Basking Shark incidental catches (1980-1983).

Date	1980	1981	1982	1983	Total
16-29 May	0	0	0	1	1
30 May-12 June	0	2	1	9	12
13-26 June	1	53	5	61	120
27 June-10 July	9	18	9	40	76
11-24 July	17	20	4	20	61
25 July-7 August	17	5	5	6	33
8-22 August	5	10	9	1	25
23 August-6 September	2	2	2	0	6
7-20 September	0	1	0	7	8
Totals	51	111	35	145	342

FIGURE 2. Locations of incidentally caught Basking Sharks by sex (1980-1983).

only animals visible at the surface but also animals swimming considerably deeper. If females more commonly swim in surface water, and are therefore visible, and males swim in the same area but at greater depths, susceptibility to incidental catch in fishing gear and directed fisheries would vary by sex. It is possible that a difference in surface activities of males and females is associated with sexual activity.

Reports of incidental catch from 1980-1983 and retrospective surveys from 1970-1980 are consistent. However, in 1981, a significant increase in the catch occurred. We believe that a subtle change in actual effort accounts for this increase. In 1981, markets developed for fins and liver so fishermen could sell incidentally caught sharks. In previous years, when Basking Sharks appeared in abundance in an area, fishermen would remove their salmon nets from the water to prevent gear damage. Because of the market in 1981 this was not the case.

Markets remained high in 1982 but Basking Shark catches on the southwest coast, in particular, were low. In 1982, inshore water on the Nova Scotia side of the Laurentian Channel warmed before surface water on the southwest coast. It is possible that Basking Sharks simply move to the nearest warm inshore

TABLE 3. Median dates of male and female catch (1980-1983).

		1980	1981	1982	1983
Female	N	7	19	4	6
	Range	28/6-6/9	26/6-21/8	28/6-23/7	1/8-7/9
	Median	11 July	6 July	8 July	13 July
Male	N	11	42	6	23
	Range	1/7-27/8	15/6-20/8	12/6-11/8	14/6-15/7
	Median	22 July	2 July	30 July	8 July
% total catch sexed		35	55	29	20

TABLE 4. Length (m) of male and female Basking Sharks.

Sex	N	Mean length	Std. Dev.	Range
Male	40	7.5	1.87	12.2-3.0
Female	27	6.9	1.82	10.7-2.4

water. In some years, like 1982, incidental catches of Basking Sharks on Cape Breton Island, Nova Scotia, are large (J. Smith, personal communication) and these may be from the same stock as animals caught in Newfoundland. This hypothesis could be tested by tagging and recapture.

Captures of immature animals were low (2.6%), occurred primarily later in the summer, and were concentrated in water off eastern Newfoundland. While these animals feed on plankton similar to that eaten by adults, they may be generally found in deeper water and are less likely to be caught. It is also probable that because of their smaller size, they are less likely to be reported. If sexual activity is the primary purpose of the inshore migration, then immature Basking Sharks may have a different summer distribution than the adults.

Acknowledgments

We would like to acknowledge Fisheries and Oceans Canada and the Newfoundland and Labrador Department of Fisheries for financial support of this work. Assistance with field work was given by Dave Aldrich, Lisa Baraff, Sue Staniforth, Dong Jin hai, Cheryl Hendrickson, Greg Keith, Ralph Owen, Inge Hindle, Alan Knoerr, Iris Silverstein, Maren Lien and others, and is gratefully acknowledged. John Green, C. C. Davis, and Hal Whitehead criticized an early draft of this manuscript and greatly improved it. Several local companies with commercial interests in Basking Sharks have been very helpful and we would especially like to acknowledge Alex Ting and Cosmas

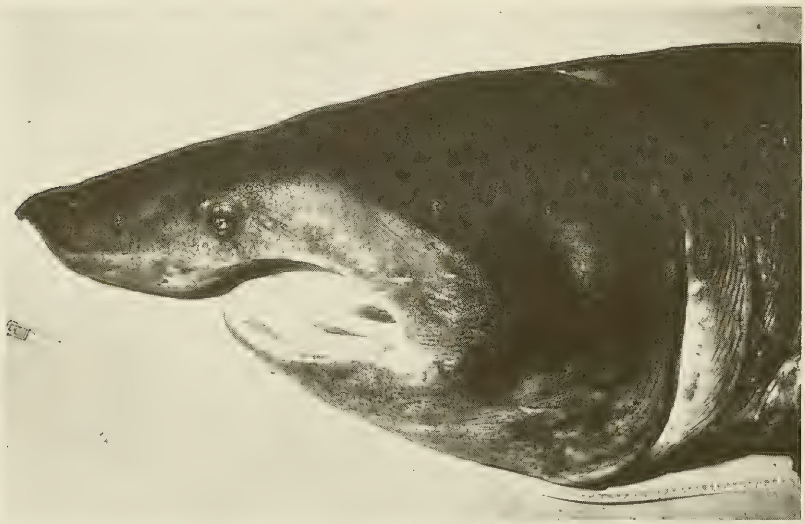

FIGURE 3. Snout characteristics of an immature Basking Shark.

FIGURE 4. Locations of incidentally caught immature Basking Sharks (1980-1983).

Ho of Terra Nova Fisheries. Finally, we would particularly like to acknowledge the many inshore fishermen that we have worked with; without their help and support we could not have done the work.

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TABLE 5. Results of retrospective survey of incidental Basking Shark catch (1970-1981). Fishermen that caught sharks in 1980/81 were sent two questionnaires. They were to fill in one survey and give the second card to a neighbour fishing in the same area that did not catch a shark in 1980/81. Sixty-four of 124 fishermen that caught sharks replied (52%); 29 fishermen that did not catch sharks replied (45%). Efforts between years did not vary significantly.

	Fishermen that caught sharks in 1980/81			Control fishermen who did not catch sharks in 1980/81		
Year	N fishing	N sharks	%	N fishing	N sharks	%
1970	41	12	29	15	2	13
1971	49	13	26	16	1	6
1972	51	13	25	16	2	12
1973	52	17	33	16	2	12
1974	54	14	26	16	2	12
1975	59	17	29	17	3	12
1976	60	21	35	17	1	6
1977	62	19	31	17	1	6
1978	63	21	33	23	0	0
1979	65	24	37	26	2	8
1980	65	36	55	28	0	0
1981	65	57	88	29	0	0

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Notes

Notes on the Occurrence of the Hornet Moth, *Sesia apiformis* (Lepidoptera : Sesiidae), New to Canada*

RAY F. MORRIS

Research Station, Agriculture Canada, P.O. Box 7098, St. John's, Newfoundland A1E 3Y3

Morris, Ray F. 1986. Notes on the occurrence of the Hornet Moth, *Sesia apiformis* (Lepidoptera: Sesiidae), new to Canada. Canadian Field-Naturalist 100(2): 253–254.

A single female Hornet Moth (*Sesia apiformis*) is reported collected 25 July 1983 at St. John's, Newfoundland and previous records for North America and England are summarized. A description of the adult and eggs from the specimen is given.

Key Words: Hornet Moth, *Sesia apiformis*, Newfoundland, Canada.

On 25 July 1983, Mr. Stan Atkins, 89 Whiteway Street, St. John's, Newfoundland submitted a female Hornet Moth, *Sesia apiformis* (Clerck), to my laboratory for identification. The moth had been captured when it alighted on the branch of a Lombardy Poplar, *Populus nigra* var. *italica* DuRoi, in Mr. Atkins' garden. This is the first record of the Hornet Moth in Newfoundland. It is not known if this discovery was the result of a stray introduction or if the species is established in the greater St. John's area.

The identity of the moth was confirmed by Dr. T. D. Eichlin, Food and Agriculture, State of California, Sacramento, California, who also pointed out that this was definitely the first record of *S. apiformis* in Canada. Dr. Eichlin reported (personal communication) that the distribution of this moth in the U.S.A. was as given by G. P. Engelhardt (1946), including New York, Connecticut, New Jersey and Pennsylvania, and that the most recent records of *S. apiformis* had been those in New York and New Jersey in 1938.

Forbes (1923) gave the distribution of the species as Europe, with stray records in the United States (Michigan; Syracuse and Long Island, New York; and Nevada). Engelhardt (1946) gave its distribution as Europe, New York, Connecticut, New Jersey and Pennsylvania, and stated that reports from inland regions to midwestern states and Eastern Canada are considered erroneous. Engelhardt listed its host plants as poplars and willows. South (1961) noted that the eastern counties of England appear to be most favoured by this insect, but it also occurs northwards to Yorkshire and southwards to Devon, with a single specimen reported from Rhyl, North Wales. In Scotland, it has been reported from some localities in the south. South believed that the species occurred in the northern half of Ireland, and larvae were also reported plentiful in young poplars growing in a marsh near the city of Waterford. South also indicated it had been recorded from Cork.

As indicated by its English name, the moth (Figure 1) is in superficial appearance very much like the European hornet, *Vespa crabro germana* Christ. It has a wing span of approximately 36 mm, and a body 23 mm long and 7 mm wide. The sides of the head, front of the palpi, sides of the back of the head, vertex, front half of tegula and metathorax are yellow. The rest of the head and thorax are dark brown. The abdomen is banded black and yellow, with segments two and four nearly all black. The wings are transparent, with forewing brown scaled along its costal margin. While contained in captivity in a 2 L polypropylene container with poplar leaves and twigs, the Hornet Moth laid 223 eggs loosely in the container. The eggs were light brown, smooth, slightly oval (0.5 mm x 0.75 mm), somewhat flattened and leathery.

Because details are not readily available in recent North American guides the following information on larvae is worth noting. South (1961) described the caterpillar as yellowish white, with a red-brown head, and a yellow plate on the first ring of its body. It feeds on the roots and lower portion of the trunks of poplar trees, probably living for three years. The brown shining chrysalis is enclosed in a cocoon of wood scrapings woven together with silk, made in late summer, in the bark or in the earth. The larva changes to a chrysalis the following spring. Moths emerge in May and June and are frequently observed resting on the stems of poplar trees in the morning. MacKay (1958) gave the

*Contribution No. 83, Research Station, Agriculture Canada, P.O. Box 7098, St. John's, Newfoundland A1E 3Y3

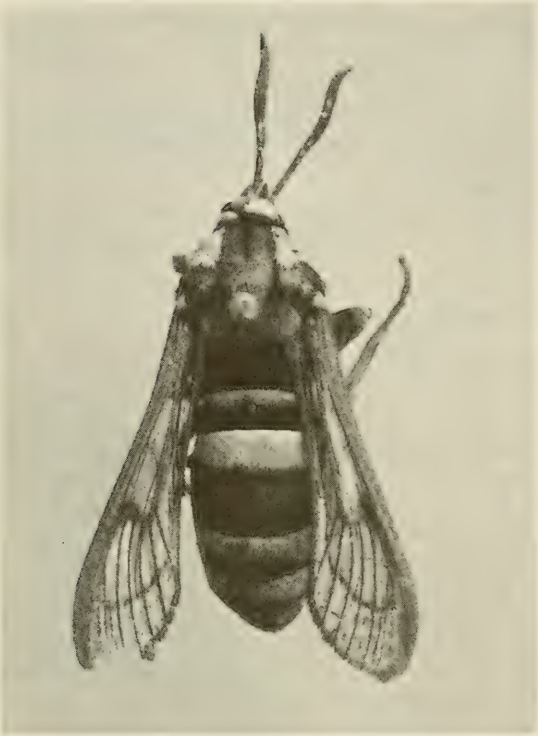

FIGURE 1. Female Hornet Moth, *Sesia apiformis* (Clerck), collected at St. John's, Newfoundland, 1983-07-25; 2.5 times natural size. (Photograph by B. G. Penney.)

length of the largest larvae examined as 30-50 mm, and indicated that the dorsal surface of the head was strongly convex (in lateral view) and comparatively smooth. Headfrontal sutures were strongly curved inward between Adf^1 and Adf^2 so that the adfrontals were distinctly narrower in this area than elsewhere, even in young instars. The spiracles were usually circular in early instars, but oval in later instars.

Acknowledgments

The assistance of J. E. H. Martin, Biosystematics Research Institute, Ottawa, in providing references, and T. D. Eichlin, Food & Agriculture, State of California, Sacramento, California, in confirming the identity of the species is acknowledged.

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A Vestigial Wing Claw on a House Sparrow, *Passer domesticus*

ROBERT W. NERO[1] and RENATE SCRIVEN[2]

[1]Manitoba Wildlife Branch, 1495 St. James Street, Winnipeg, Manitoba R3H 0W9
[2]722 Buckingham Road, Winnipeg, Manitoba R3R 1C2

Nero, Robert W., and Renate Scriven. 1986. Vestigial wing claw on a House Sparrow, *Passer domesticus*. Canadian Field-Naturalist 100(2): 255.

A juvenile male House Sparrow, *Passer domesticus*, had a vestigial wing claw at the base of digit II on one wing. This is apparently the fourth known instance of a passerine with a wing claw, and only the second in North America.

Key Words: House Sparrow, *Passer domesticus*, wing claw, vestigial.

Vestigial claws were found on the wings of birds in 14 of 21 orders examined by Fisher (1940). Although he examined 241 specimens of 68 genera in about 20 families of the order Passeriformes, he found none with claws. Since then, wing claws have been reported for the Great Kiskadee, *Pitangus sulphuratus*, (Friedmann 1952), the White-necked Crow, *Corvus leucognaphalus* (Baumel 1953), and the Red-winged Blackbird, *Agelaius phoeniceus* (Nero 1957). We now record a wing claw in the House Sparrow, *Passer domesticus*. This is only the fourth known instance of a passerine with a wing claw, and only the second in North America.

Scriven discovered the claw while examining the wings of a dead juvenile male House Sparrow. A partial albino, this bird was received when newly-fledged. It was sacrificed on 17 August 1984, when it was about 2½ months old.

The claw, 1.5 mm in length, was attached by tubular epidermal tissue on the ventral side of the right wing, near the base of digit II (the alular phalanx, cf. Nero and Loch 1984). It was fairly closely appressed to the fleshy surface, but was not parallel to the alular phalanx. This claw, although actually tiny, is relatively large for the size of the bird, compared to claws 4 mm in length found on adult Great Gray Owls, *Strix nebulosa* (Nero and Loch 1984).

Tapered from the base to the tip, the claw was roughly wedge-shaped in cross-section. It looked like a minute black thorn. Under a microscope it could be seen to be composed of glossy, dense material. Its colour varied from opaque-blackish at the base and along the heavier "top" edge, to translucent reddish-brown along the lower portion. Several fine, dark lines ran parallel to its length on the sides. The pointed end was rounded in cross-section, and the claw had a hollow base.

Persons handling passerine birds (especially dead ones) should perhaps make a greater effort to look for wing claws. A careful examination of the alular area, especially at the tip and base of the alular phalanx, might uncover additional records of vestigial wing claws.

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Sightings of a Black-throated Sparrow, *Amphispiza bilineata*, and a Black Vulture, *Coragyps atratus*, in British Columbia

DANIEL F. BRUNTON[1] and TERRY PRATT[2]

[1]2704 Marie Street, Ottawa, Ontario K2B 7E4
[2]116 Oak Street, Leamington, Ontario N8H 2C9

Brunton, Daniel F., and Terry Pratt. 1986. Sightings of a Black-throated Sparrow, *Amphispiza bilineata*, and a Black Vulture, *Coragyps atratus*, in British Columbia. Canadian Field-Naturalist 100(2): 256–257.

A singing male Black-throated Sparrow, *Amphispiza bilineata*, observed at Spotted Lake east of Osoyoos, Okanagan Valley, on 27 June 1981 represented the second documented observation in British Columbia (and Canada). A Black Vulture, *Coragyps atratus*, was observed on 25 June 1981 near Okanagan Falls, representing the first documented sighting in British Columbia.

Key Words: Black-throated Sparrow, *Amphispiza bilineata*, Black Vulture, *Coragyps atratus*, Okanagan Valley, British Columbia.

In June 1981 we observed a Black-throated Sparrow, *Amphispiza bilineata*, and a Black Vulture, *Coragyps atratus*, in the southern Okanagan Valley of British Columbia. These species are extremely rare vagrants to Canada (Godfrey 1966). Detailed reports of our observations (with copies of the original field notes) have been sent to the British Columbia Provincial Museum Ornithology Department, the University of British Columbia Department of Zoology, and the National Museum of Natural Sciences Ornithology Section. The following are the highlights of these observations.

(1) *Black-throated Sparrow*

The bird was observed in open sage (*Artemisia* spp.) on the arid, sandy slopes above Spotted Lake, 5 km east along Highway 3 from Osoyoos. We observed the bird under clear, sunny conditions at distances from 65 m to 15 m for about a minute of uninterrupted viewing at 0800 h on 27 June 1981. It was seen to fly in across the sage, land on a roadside fence wire, sing repeatedly, then fly off into the sage once more. It was not seen again by ourselves or by other observers who searched for it during the next three days (S. A. Cannings, personal communication).

The major field marks observed included the following: a dark sparrow with a solid black bib extending from its bill well down onto its breast; side of head very dark, with a distinct white line above the eye and along the jawline; pale white unstreaked belly; an unstreaked brown back (seemingly a warm chocolate-brown colour); tail all dark (no white noted); song was two rolling, musical notes following a much longer, lower trill.

There is no other North American sparrow with the above combination of field marks (Scott et al. 1983). Though we did not observe any white on the tail, this minor feature appears to be the only field mark for this species that we did not note.

The Black-throated Sparrow has been reported twice before in Canada. A specimen was collected at Wells Gray Park, also in interior British Columbia, in June 1959 (Godfrey 1961). A single bird was reported from Barrhead, Alberta, in May 1979 (Gollop 1979; Ebel 1979), but the observer was unable to document his observations to either reporter or to us (P.S. Norris, personal communication) and has no material evidence to support the identification.

(2) *Black Vulture*

One bird was observed soaring high overhead along a cliff-edge (on up-drafts) about 1 km south of Okanagan Falls Provincial Campground along the Green Lake road on 25 June 1981. We observed the bird from approximately 400 m through binoculars and through a 25x – 40x telescope for 15 minutes from about 1550 h under bright, sunny conditions without glare. It flew briefly in company with a pair of Golden Eagles (*Aquila chrysaetos*) and a Red-tailed Hawk (*Buteo jamaicensis*) and eventually soared off in a northwesterly direction. It was not observed again by ourselves or by other observers who searched for it during the next few days (S. A. Cannings, personal communications).

The major field marks observed were approximate size of Golden Eagle (direct comparison), with flat (no dihedral), rounded, very broad wings and a wide, stubby tail; tail uniformly dark (apparently with feet extending out beyond it); very small head (the bird appearing to be 'headless' at first glance); primaries spread open (in 'fingers' pattern typical of vultures); bird a blackish-brown colour overall with the hind portion of the underwing being uniformly paler than the forewing and with a white patch visible (from

above and below when the bird turned) near the end of the wings at the base of the primaries.

The broad, flat wings, tiny head (proportionally much smaller than that of the eagles) and very short, all-dark tail (possibly shorter than the extended feet) eliminate other raptors except for a very atypical Turkey Vulture (*Cathartes aura*). The flat wings, wide and extremely short tail, and the confined white areas at the end of the wings eliminate this possibility.

The Black Vulture is a very rare vagrant to eastern Canada (Godfrey 1966) and is being seen along the northern limit of its range more frequently as it expands its breeding range to the northeast (Scott et al. 1983). We are aware of no previous sightings from western Canada. In July 1982, however, a Black Vulture was photographed at Kluane Lake, Yukon Territory (Grunberg 1984). The photograph has been submitted to the National Museum of Natural Sciences, Ottawa, and has been verified by W.E. Godfrey (personal communication). The Black Vulture has also been reliably reported along the western coast of the United States on a few occasions but has not been included on state lists because of the possibility of these birds being escapees (Roberson 1980).

Our report, then, constitutes the first documented sighting from British Columbia and western Canada.

Acknowledgments

Our thanks to W. E. Godfrey and B. M. Di Labio of the National Museum of Natural Sciences, Ottawa, for information on various records for these species, and to P. H. R. Stepney of the Provincial Museum of Alberta and J. B. Gollop of the Canadian Wildlife Service, Saskatoon, for assistance in checking the recent Alberta report of Black-throated Sparrow. These observations were made while we were conducting a tour of the Okanagan Valley for Top Flite Nature Tours of Leamington, Ontario.

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Mongolian Plover, *Charadrius mongolus*, in Alberta

Richard E. Salter, Judith A. Smith, William R. Koski, and Joanne M. Barbeau

LGL Limited, environmental research associates, 1860, 500 - 4 Avenue S.W., Calgary, Alberta T2P 2V6

Salter, Richard E., Judith A. Smith, William R. Koski, and Joanne M. Barbeau. 1986. Mongolian Plover, *Charadrius mongolus*, in Alberta. Canadian Field-Naturalist 100(2): 257–258.

A single Mongolian Plover (*Charadrius mongolus*) observed in June 1984 north of Fort McMurray, Alberta, represents the first record of this Asiatic species in Alberta and only the second record for Canada.

Key Words: Mongolian Plover, *Charadrius mongolus*, Alberta, Canada.

On 18 June 1984, while conducting waterbird surveys for Syncrude Canada Limited, we observed a single Mongolian Plover (*Charadrius mongolus*) in full breeding plumage on the Syncrude site north of Fort McMurray, Alberta (57°06′N, 111°39′W). This is the first record of this species in Alberta, only the second record in Canada, and one of the few inland records for North America. The bird was observed in association with an 8 ha pool of shallow standing water and long, narrow spits and islands in the bottom of a gravel borrow pit (total denuded area about 70 ha) located in a mixedwoods/muskeg area 3.5 km

west of the Athabasca River. It was first seen under excellent lighting conditions and from as close as 15 m between 1320 h and 1410 h, and was identified while in sight from a colour plate and description in Robbins et al. (1983). Several Spotted Sandpipers (*Actitis macularia*), Killdeer (*Charadrius vociferus*) and Wilson's Phalaropes (*Phalaropus tricolor*) also were present in the area, but the Mongolian Plover remained alone and did not seem to be associated with any of these. The bird was still present when we returned at 1605 h and several colour slides were taken during the next 45 minutes. Two of these have been deposited with the National Museum of Natural Sciences in Ottawa.

This species breeds in central and northeast Asia, dispersing during winter to as far south and east as Australia and New Zealand, and west to Africa (King et al. 1975). It is considered to be one of the commonest Asiatic shorebirds (Smythies 1953, 1981), but North America is peripheral to its normal range and it is only rarely seen on this continent. Most North American records are from Alaska, where it occurs as a rare spring migrant in the Bering Sea (from the western Aleutians to St. Lawrence Island), as a casual or probable breeder along the western mainland coast and in the Brooks Range, and as a summer/fall visitor or very rare fall migrant along the coast and offshore (Kessel and Gibson 1978). South of Alaska there are only seven previous North American records: one from Louisiana during April (Littlefield et al. 1977), one from Ontario during May (McRae 1985), three from California during July-October (Evens and LeValley 1981; McCaskie 1983a, 1983b), and two from Oregon during September-October (Mattocks and Hunn 1980; Roberson 1980). All but the Ontario record are from marine coastal areas. The Louisiana record and one of the California records may have represented overwintering birds (Roberson 1980; McCaskie 1983b) but most North American sightings of this species, including our own, apparently are of vagrants or extralimital migrants.

Acknowledgments

The waterbird surveys during which this sighting was made were funded by Syncrude Canada Limited. We thank W. E. Godfrey for confirming our identification from the slides deposited at the National Museum of Natural Sciences. We would also like to thank D. C. Thompson of Syncrude and P. L. McLaren and W. J. Richardson of LGL Limited for their comments on the manuscript.

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Grizzly Bear, *Ursus arctos*, Usurps Wolf, *Canis lupus*, Kill

GARRY E. HORNBECK and BRIAN L. HOREJSI

Western Wildlife Environments Consulting Ltd., P.O. Box 3129, Station B, Calgary, Alberta T2M 4L7

Hornbeck, Garry E., and Brian L. Horejsi. 1986. Grizzly Bear, *Ursus arctos*, usurps Wolf, *Canis lupus*, kill. Canadian Field-Naturalist 100(2): 259–260.

A subadult female Grizzly Bear (*Ursus arctos*) took possession of a Moose (*Alces alces*) carcass from three or four Wolves (*Canis lupus*). Evidence indicates that the Wolves made the kill and fed without interruption for several days before the bear arrived. This observation demonstrates the potential for direct competition between bear and Wolf while emphasizing the bear's dominance and the opportunistic nature of its feeding habits.

Key Words: Grizzly Bear, *Ursus arctos*, Wolf, *Canis lupus*, contested kill.

During late summer 1983, while studying the movements and feeding habits of Grizzly Bears (*Ursus arctos*) in west-central Alberta (54°55′N, 119°08′W), we radio-tracked a grizzly to a Moose (*Alces alces*) kill. Evidence indicated that Wolves (*Canis lupus*) made the kill and that the grizzly arrived sometime later, presumably after scenting the decaying carcass. The following is an account of the events leading to this observation and our interpretation of the evidence.

At 1225 h on 27 August 1983, an instrumented 4-year-old female Grizzly Bear was approached on foot by the senior author and an assistant in an effort to locate feeding sign. The bear had been tracked to this location the previous day. Three days prior to the 26th, the bear was 9.5 km east of the kill site.

When 300 m from the bear we encountered Wolf sign; there were numerous trails through the vegetation, several bedding sites, and several meat scats. We were then met by a chorus of howls from Wolves which were less than 100 m from us. Based on the number of different vocalizations, three or four Wolves were present. As we continued our approach it became evident that the Grizzly Bear was reluctant to withdraw. At that juncture we detected the odor of a carcass. From the direction of the bear, her behavior, and the direction of the Wolves, it was obvious that the bear was in possession of the carcass while the wolves remained nearby. As we left the area, we found on one of the Wolf trails a 2 kg piece of meat from the carcass.

On 29 August the authors returned to the kill by helicopter. The bear was 700 m from the remains of the carcass and was moving away as we approached. No Wolves were observed as we circled the area. We immediately landed and inspected the kill. The bear had dug the site up, exposing mineral soil over an area roughly 9 by 6 m. The prey was a 15-month-old male Moose. Utilization of the carcass was complete; there was no meat remaining on any of the bones. The skeleton was disarticulated and the bones were scattered. We estimated that the remains were one week old. The Moose had been killed on or about 22 August. Hair had not fallen from the hide and unexposed flesh was still red. This evidence discounts the possibility that the carcass had been lying for any length of time. This also indicates the Wolves were not scavenging.

Abundant Wolf sign and the condition of the skeleton combine to suggest that Wolves made the kill and fed extensively on the carcass before the bear arrived. Their meat scats were readily identified and Wolves characteristically scatter bones from the skeleton of ungulate kills (Mech 1970). The meat scrap some distance from the carcass is also typical of the feeding behavior of Wolves (Murie 1981). Our experience with bears indicates, on the other hand, that bears commonly leave an ungulate skeleton intact, the bones loosely attached with shredded ligaments and pieces of hide. As well, bones are not often broken, splintered or gnawed. These differences in skeletal remains are diagnostic and reflect differences in the dentition of the Wolf and bear. The Wolves' carnivore dentition permits a shearing force that cuts ligaments and breaks bones while the grizzly is unable to do this with teeth adapted for omnivory. In addition, we were unable to find any bear scats at the site, suggesting the bear had not consumed substantial quantities of meat.

Bear-Wolf encounters have not been widely documented, indicating the difficulty in making such observations. Little is known regarding mortality amongst participants when in direct competition at a carcass. Ballard (1982) speculated that the frequency of bear-wolf encounters is determined by prey density. He indicated that in his Alaska study area there was a disproportionate number of contested kills in an area of relatively low Moose density and hypothesized that there was an insufficient number of Moose for both bear and Wolf under those circumstances. Strong

evidence in support of that argument, however, is not presented.

It is our contention that prey availability is unlikely to have a bearing on the frequency of contested kills for several reasons. First, the Grizzly Bear does not rely on an animal prey base for its existence, as does the Wolf. The grizzly is primarily a vegetarian but will use any high quality or concentrated food source available, be it garbage, salmon, or berries. In addition, our telemetry studies of the grizzly indicate that daily movements involve a measure of randomness which suggests a high degree of opportunism, a strategy that maximizes chance encounter. Because an ungulate carcass is a large and concentrated food source it would be extremely maladaptive for any grizzly to ignore a carcass, regardless of who may be at the carcass or what other food items may be available. This strategy dictates that any subadult or adult bear that becomes aware of a carcass will investigate, regardless of how often carcasses may be encountered or what may be involved in attempting to claim the carcass. As Murie (1981) suggests, a hungry adult bear is not likely to be denied by Wolves. The only possible source of denial may be the presence of man, and that may depend on the bear's experience.

Acknowledgments

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Purple Reed-grass, *Calamagrostis purpurascens*, in Algonquin Park, Ontario

DANIEL F. BRUNTON and KAREN L. McINTOSH

2704 Marie Street, Ottawa, Ontario K2B 7E4

Brunton, Daniel F., and Karen L. McIntosh. 1986. Purple Reed-grass, *Calamagrostis purpurascens*, in Algonquin Park, Ontario. Canadian Field-Naturalist 100(2): 260–261.

A new Ontario station for the arctic/subarctic and cordilleran grass *Calamagrostis purpurascens* is reported from Greenleaf Lake, Algonquin Park, Nipissing District. This is the third locality for this rare species in Ontario and the southernmost for eastern North America. It is growing with other northern and western species and is believed to be an element of a relict floral and faunal association from the period of subarctic/arctic conditions which prevailed at the site ca. 11 000 years B.P. The other Ontario stations for *C. purpurascens* are also disjunct populations and are found near the north shore of Lake Superior ca. 925 km to the west-north-west.

Key Words: *Calamagrostis purpurascens*, Poaceae, Algonquin Park, Ontario, relict flora, Fossmill Outlet.

The Purple Reed-grass (*Calamagrostis purpurascens* R.Br.: Poaceae) is a common grass of cordilleran and arctic/subarctic areas in northwestern North America and is also found in a few widely disjunct stations in eastern North America (Calder and Taylor 1968; Scoggan 1978; Given and Soper 1981). It is considered rare in all eastern Canadian provinces in which it is known (Riley and Reznicek 1984; Bouchard et al. 1983). Until now, it was known only from two locations in Ontario, both in the Thunder Bay District: on the Sibley Peninsula near Thunder Bay and at South Fowl Lake along the Minnesota border (Dore and McNeill 1980; Riley and Reznicek 1984).

On 9 September 1984 we collected specimens of *C. purpurascens* on a dry, north-facing granite ledge of a

small cliff along the shore of Greenleaf Lake in eastern Algonquin Park, Nipissing District, Ontario, at 45°53′N, 77°57.5′W. It was found growing in a thick duff which was composed mostly of the roots of *Agropyron trachycaulum* (which dominated the site). The plants were growing under light shade provided by scattered young Hemlock (*Tsuga canadensis*), Cedar (*Thuja occidentalis*) and White Birch (*Betula papyrifera*), with scattered plants of Strawberry (*Fragaria virginiana*) and Encrusted Saxifrage (*Saxifraga aizoon*). The *Calamagrostis* was scattered quite commonly along this ledge for four or five meters. Voucher specimens (*Brunton* and *McIntosh 5289*) have been deposited in the herbarium of the Algonquin Park Museum (APM) and that of D.F. Brunton (DFB) (Herbarium acronyms follow Boivin 1980). This station is approximately 925 km east-south-east of the next nearest Ontario location at Thunder Bay. It is almost 700 km south of the closest Quebec station at Mistassini Lake (Bouchard et al. 1983). It also represents the most southerly collection for eastern North America (cf. Riley and Reznicek 1984).

The cliffs at Greenleaf Lake have been recognized for some time as an important location for provincially and/or regionally rare vascular plants (cf. Britton et al. 1975). A number of these, such as the Encrusted Saxifrage (*Saxifraga aizoon*), Mountain Cliff Fern (*Woodsia scopulina*), Rock-cress (*Draba glabella*) and Green Alder (*Alnus rugosa*), are northern and western species. It is believed that they are relicts from the arctic/subarctic environment that characterized this area ca. 11 000 years B.P. (cf. Terasmae and Hughes 1960). Martin and Chapman (1965) have demonstrated that a relationship exists between the presence of relict populations of northern crustaceans and fish in certain lakes (including Greenleaf Lake) and the post-glacial events surrounding the drainage of glacial Lake Algonquin through the Fossmill Outlet. The Fossmill Outlet was a prehistoric river network that drained glacial Lake Algonquin along a course across what is now eastern Algonquin Park and through the Petawawa and Barron River systems to the Ottawa River at Petawawa (Chapman 1954).

The occurrence of *Calamagrostis purpurascens* at Greenleaf Lake offers additional evidence that some floral and faunal elements in eastern Algonquin Park are relicts of a post-glacial, subarctic environment and that the establishment of such populations is related to the presence of a major drainage outlet of glacial Lake Algonquin.

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White Moose, *Alces alces*, Sightings in Northern Ontario

EDWARD R. ARMSTRONG[1] and GARY BROWN[2]

Ontario Ministry of Natural Resources, P.O. Box 730, Cochrane, Ontario P0L 1C0
[1]Present Address: Ministry of Natural Resources, Hwy. 101, Wawa, Ontario P0S 1K0
[2]Present Address: Ministry of Natural Resources, Box 640, Geraldton, Ontario P0T 1M0

Armstrong, Edward R., and Gary Brown. 1986. White Moose, *Alces alces*, sightings in northern Ontario. Canadian Field-Naturalist 100(2): 262–263.

Repeated observations of a white cow Moose (*Alces alces*) within a radius of 6.5 km and over a period of five years are documented. A white Moose was observed with a brown calf in 1982; a second observation in 1983 was of a white Moose with a white calf.

Key Words: Moose, *Alces alces*, albinism, Ontario, reproduction.

A number of white Moose (*Alces alces*) observations have recently been made in the Cochrane District of northeastern Ontario. These observations collectively reveal information on the survival, reproduction, and incidence of white Moose in this area.

On 31 July 1978 a white Moose was observed by Brown approximately 70 km east of Cochrane, Ontario. The Moose was observed and photographed from a helicopter for approximately 10 minutes at a minimum altitude of 20 m. The Moose was of adult size and unantlered, thus presumed to be a cow. The body and head appeared all white but with dark lower legs and some small brown body markings that may have been mud splashings. An independent observation of a white Moose was reported to Brown approximately one year later. This observation was made approximately 1.2 km south of the original sighting location by an anonymous hunter to whom the location of the original sighting had not been disclosed. In mid-August of 1982, Mr. Babin, a long-time trapper resident in the area, observed a white cow Moose with a brown calf on the shore of a river approximately 7 km southwest of the original observation point. On 10 August 1983, a white Moose with a white calf was reported to our office by a private aircraft pilot. This observation was approximately 5.6 km north of the 1978 sighting location. We verified this observation by locating the white cow and calf on 12 August 1983 on the edge of a wetland area adjacent to a Black Spruce (*Picea mariana*) forest. The Moose were viewed and photographed from an altitude of between approximately 50 and 100 m. Both Moose appeared to be entirely white. The maximum distance separating all four observations was approximately 13 km.

Documented sightings of white or albino Moose are rare, although albinism has been reported in Moose (Franzmann 1978). Sightings of white Moose have often been reported in Alaska (A. Franzmann, personal communication). W. Troyer (1980. Records of white Moose in the McKinley Park area, Alaska. Proceedings of the Alaska Interagency Moose Meeting: *Unpublished*) documented 31 observations of white or partially white Moose in the McKinley Park area. White and partially white Moose have been reported in popular accounts. A newspaper article from northwestern Ontario (*Kenora Miner and News*, 5 April 1978) describes a bull Moose "with pink eyes and part white colouration" that was shot approximately 65 km east of Kenora. A. Stasas of the Sioux Lookout office of the Ministry of Natural Resources gathered reports of five "albino" Moose and one "pure white" Moose being harvested, one "albino" Moose being seen in July 1978, and several less well documented sightings of Moose "exhibiting some degree of albinism" over a period of approximately 12 years (A. Bisset, personal communication). A 2½ year old male "albino" Moose was collected at Martin Lake, Nipissing District, Ontario in 1913. It was greyish white with brown splotches (R. L. Peterson, personal communication).

These observations of a white cow over a period of five years within a radius of 6.5 km probably indicate one of two situations. If all observations pertain to one female Moose, at least 1½ years old in 1978, this atypically coloured Moose was able to survive for at least 6½ years in an area of moderate Gray Wolf (*Canis lupus*) densities and relatively low hunting pressure. This situation would be consistent with Goddard's (1970) observation that cow Moose are quite sedentary from year to year, moving 2.0 to 3.2 km from summer to summer, and 1.2 to 9.7 km from summer-fall of one year to a winter of a succeeding year. If this is one Moose, it is particularly notable that it was able to attract and successfully mate with a bull Moose on at least two occasions despite its unusual coloration. W. Troyer's (see above) documented sightings included one instance of a brown cow with a white calf, and one instance of a

white cow with a brown calf. An albino Caribou (*Rangifer tarandus granti*) cow has also been reported with a typically coloured calf (Curatolo 1979). The alternative explanation is that the observations represent more than one white Moose, thus reflecting a higher than average incidence of white Moose in the population. The reports of several white Moose over time in the Sioux Lookout and McKinley Park areas would support this explanation. The actual case in our study area may reflect a combination of the two suggested situations. At a minimum, there are now two white Moose in the local population.

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Addendum

An all-white bull Moose, wear-classed as 2½ years old, was shot on 5 October 1985 very near the 12 August 1983 observation sites of the white cow and white calf.

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Nestling Birds as Prey of Breeding Long-billed Curlews, *Numenius americanus*

CAMERON P. GOATER and ALBERT O. BUSH

Department of Zoology, Brandon University, Brandon, Manitoba R7A 6A9

Goater, Cameron P., and Albert O. Bush. 1986. Nestling birds as prey of breeding Long-billed Curlews, *Numenius americanus*. Canadian Field-Naturalist 100(2): 263–264.

A nestling passerine was found in the upper digestive tract of an adult female Long-billed Curlew (*Numenius americanus*) collected in Alberta.

Key Words: Long-billed Curlew, *Numenius americanus*, diet, Alberta.

Terrestrial insects are regarded as the principal food of Long-billed Curlews (*Numenius americanus*) on their inland breeding grounds (reviewed by Stenzel et al. 1976). Timken (1969) reported the presence of a nestling fringillid in the esophagus of one of two Long-billed Curlews collected in South Dakota. He noted that insects were absent in early June (when snowdrifts were still present) and were still scarce in late June when the curlews were collected. He reported that ground-nesting fringillids were abundant at the time the curlews were collected and suggested that the scarcity of insects forced curlews to engage in opportunistic feeding.

As part of an investigation of the parasite fauna of shorebirds on their breeding grounds, five adult Long-billed Curlews (2 males, 3 females) were collected on 6 and 7 June, 1984 from the prairies surrounding Cowoki Lake, Alberta (50° 35′N, 111° 40′W). The ovaries of all females had developing follicles. The birds were collected with a shotgun, placed individually in plastic bags, and frozen on dry ice. Birds remained frozen until subsequent examination in the laboratory.

The proventriculi and gizzards of all five curlews contained insect fragments (primarily grasshoppers [Orthoptera], caterpillars [Lepidoptera], beetles

[Coleoptera]), and seeds from various unidentified plants. One female curlew contained a partially digested nestling passerine in the lower esophagus and upper proventriculus. The passerine (10.7 g, 71 mm T.L.) was covered with a mixture of pin-feathers and down. The state of decomposition of the nestling precluded further identification. Although the nestling caused great distension of the esophagus, the curlew had a large grasshopper distal to the location of the bird. Based on five years work in the same area, insects (particularly grasshoppers) were abundant, while ground-nesting passerines were not (A. O. Bush, personal observation).

This observation lends further credibility to the argument that curlews are opportunistic feeders on their inland breeding grounds, in marked contrast with their apparently specialized diet on salt water wintering grounds (Stenzel et al. 1976). Our observations suggest that feeding on nestling birds is not wholly dependent upon lack of normal prey species.

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Savannah Sparrow, *Pusserculus sandwichensis*, Reproductive Success

GISÈLE LAPOINTE and JEAN BÉDARD

Département de biologie, Université Laval, Ste-Foy, Québec G1K 7P4

LaPointe, Gisèle, and Jean Bédard. 1986. Savannah Sparrow, *Passerculus sandwichensis*, reproductive success. Canadian Field-Naturalist 100(2): 264–267.

Savannah Sparrow (*Passerculus sandwichensis*) breeding phenology and reproductive success were studied at Isle Verte, Québec, from 1976 to 1980. The span of nest initiation, clutch size, number of young fledged and causes of egg and nestling mortality are compared with similar data on five other populatons of the same species in different geographic areas. Multiple nesting tendencies vary among these populations and appear to be related more to reduced predation pressure than to latitude or geographic location.

Key Words: Savannah Sparrow, *Passerculus sandwichensis*, clutch size, breeding success, mortality factors, Québec.

The Savannah Sparrow (*Passerculus sandwichensis*) breeds in a wide geographic range and is thus subjected to varying conditions of climate, vegetation and phenology. Environmental variability is known to influence reproductive success in general, so availability of such information in the literature is essential for comparing populations. Our objective is to provide nesting success data from a Savannah Sparrow population occupying an extremely productive tidal marsh–abandoned fields ecotone in eastern Québec. Our 20-ha study area was located in the Isle Verte National Wildlife Area (48°02′N, 69°18′W), on the mainland 225 km northeast of Québec City (*see* Bédard and LaPointe 1984 for a full description of the habitat). Each year, the nesting behaviour of about 45 pairs of banded individuals was monitored from April to August (1976, 1977, 1978 and 1980), but nests were found only between 20 May (earliest) and 17 July (latest). The status of each nest found was recorded during daily visits to the study area.

Nest initiation (including renesting) spanned 50 days in 1976, 46 in 1977, 53 in 1978, and 58 in 1980. Periods of comparable length for the same species have been found in Saskatchewan (54 days, 52°N: Lein 1968), mainland Nova Scotia (61 days, 45°N: Welsh 1975) and on Kent Island, New Brunswick (44 days, 44.5°N: Dixon 1978). In Michigan (44°N),

Potter (1974) also found a similar span of 57 days. However, two populations diverge considerably in this respect. The initiation period was substantially longer on Sable Island, Nova Scotia (85 days, 44° N: Stobo and McLaren 1975), whereas in a tundra population at LaPerouse Bay (58.5° N) it lasted a mere 23 days during two successive seasons (Weatherhead 1979). Latitudinal variation does not fully account for these exceptions. Although the arctic climate might explain a reduction in length, the much longer season on Sable Island cannot be similarly accounted for since it is located at almost the same latitude as Kent Island and mainland Nova Scotia. Milder conditions on Sable Island (higher temperatures from June to August) and a later first frost may account for the longer initiation period on that insular site.

Clutch size did not vary among years (Table 1). The annual variation of the number of young hatched from the nests completing incubation was likewise minimal. However, the number of young fledged from successful nests varied considerably from year to year. Over half of all the eggs laid hatched, but only about 35% of them survived to fledging (Table 2). Success was lowest in 1977 when only 15% of all eggs laid survived to the fledging stage. The weather that summer was very cold and rainy. In comparison, Welsh (1975) reported a high success rate for a population of Savannah Sparrows in coastal Nova Scotia: only one nest was lost (human disturbance) out of a total of 24 and the only egg losses were due to hatching failure. This is surprising since the population was located in a recreational area with considerable human traffic. Predation was very low in that mainland site.

Predation was the most important mortality factor at Isle Verte, accounting for one-third of overall losses (Table 2). We observed nest predation by Domestic Cats (*Felis catus*), Common Crows (*Corvus brachyrhynchos*) and Short-tailed Weasels (*Mustela erminea*), in order of decreasing importance. Nest abandonment was the second major cause of mortality, accounting for more nestling losses than egg losses. Abandonment generally followed prolonged and heavy rains, so that mortality due to weather is also included in this category. Observers' effect must be discounted as we did not visit nests when bad weather prevailed. An appreciable number of nests failed because of flooding by high tides. Tides affected nests with eggs more often than nests with young. Finally, "unnatural" causes include observer-induced mortality.

Losses during the nestling stage, though high in this study, remain comparable to values published for other passerines. Ricklefs (1969) reported a mean value of 42.9% losses due to predation in six passerine species. Figures of the same magnitude have appeared in a number of studies since then (*see* Wittenberger 1976 for a detailed discussion of this topic). In the Savannah Sparrow, Dixon (1978) singled out predation as by far the major cause of egg losses because of the presence of a major gull colony on Kent Island, whereas bad weather seemed to play a very minor role. Dixon reported only one clear case of clutch desertion following heavy rain, but at Isle Verte 20% of all egg losses and 38.8% of all nestling losses could be directly attributed to bad weather. Dixon's broad category of "desertion" may, however, have included an additional percentage of such cases.

TABLE 1. Mean clutch size, number of young hatched and number of young fledged per nest for the Isle Verte Savannah Sparrow population during years 1976, 1977, 1978 and 1980 (replacement clutches are included).

Year	Clutch size $\bar{X} \pm$ S.E. (n)	Number of young per hatched nest $\bar{X} \pm$ S.E. (n)	Number of young fledged: Per nest $\bar{X} \pm$ S.E. (n)	Number of young fledged: Per successful nest $\bar{X} \pm$ S.E. (n)
1976	4.03 ± 0.08 (32)	3.54 ± 0.16 (26)	2.12 ± 0.29 (32)	3.24 ± 0.15 (21)
1977	4.03 ± 0.10 (61)	3.22 ± 0.21 (32)	0.62 ± 0.16 (61)	2.53 ± 0.32 (15)
1978	4.08 ± 0.11 (50)	3.59 ± 0.16 (39)	2.32 ± 0.25 (50)	3.24 ± 0.17 (33)
1980	3.80 ± 0.07 (71)	3.27 ± 0.12 (44)	1.24 ± 0.18 (71)	2.75 ± 0.17 (32)
All years	3.97 ± 0.05 (214)	3.40 ± 0.02 (141)	1.41 ± 0.11 (214)	2.98 ± 0.10 (101)

TABLE 2. Causes of egg and nestling mortality, and reproductive output of the Isle Verte Savannah Sparrow population from 1976 to 1980.

	1976	1977	1978	1980	Total	% of individuals	% of losses
Eggs laid	129	246	204	270	849		
(Number of nests)	(32)	(61)	(50)	(71)	(214)		
Egg losses:							
Predation	12	41	25	35	113	13.3	30.5
Tide	12	23	8	27	70	8.2	18.9
Abandonment	0	48	10	15	73	8.6	19.7
Failure to hatch	3	12	11	27	53	6.2	14.3
Unnatural	0	5	1	5	11	1.3	3.0
Unknown	11	14	8	17	50	4.6	13.5
Total	38	143	63	126	370	42.3	100.0
Young hatched	91	103	141	144	479		
(% of eggs)	(70.5)	(41.9)	(69.1)	(53.3)	(56.4)		
Nestling losses							
Predation	5	23	19	17	64	13.4	36.0
Tide	8	0	4	4	16	3.3	9.0
Abandonment	1	33	6	29	69	14.4	38.8
Unnatural	5	0	0	0	5	1.0	2.8
Unknown	4	9	5	6	24	5.0	13.5
Total	23	65	24	56	178	37.2	100.0
Young fledged	68	38	107	88	301		
(% of eggs)	(52.7)	(15.4)	(52.4)	(32.6)	(35.5)		
% of young hatched	74.4	36.9	75.9	61.1	62.8		

Only a moderate proportion (45 of 133 pairs, or 34% in years 1977, 1978 and 1980) of the breeding pairs made more than one nesting attempt. Of these 45, 32 had failed the first time. Likewise, Dixon (1978) and Potter (1974) also found that few birds produced more than one successful nest per year. Most second nestings (20/27; Dixon 1978) and all subsequent nests were preceded by failures on Kent Island. However, over half (8/15) of the pairs studied by Welsh (1975) attempted at least a second time and only two had not succeeded in their first attempt. The Sable Island Savannah Sparrow pairs easily manage to rear three and even four broods in a single season (Stobo and McLaren 1975; Ross 1980) because of the long initiation span and the long breeding season, as well as a low failure rate (90% survival of eggs to fledging; predation was very limited).

It is not immediately clear why the tendency to renest varies from one study area to the other. On Sable Island, renesting is not imposed by high failure rates and yet occurs on a large scale whereas renesting at Isle Verte, in Michigan, and on Kent Island appears to be restricted mainly to first time failures. In each of these three latter sites, whether insular or continental, predation is a major cause of nest failure. Such contradictions cannot be resolved without more information on the population dynamics of this species in other parts of its range.

Acknowledgments

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Response of Mute Swans, *Cygnus olor*, to a Snapping Turtle, *Chelydra serpentina*, Attack on a Cygnet

Harry G. Lumsden

Ontario Ministry of Natural Resources, Wildlife Research Section, P.O. Box 50, Maple, Ontario L0J 1E0

Lumsden, Harry G. 1986. Response of Mute Swans, *Cygnus olor*, to a Snapping Turtle, *Chelydra serpentina*, attack on a cygnet. Canadian Field-Naturalist 100(2): 267–268.

A Trumpeter Swan, *Cygnus buccinator*, cygnet was pulled under the water by a Snapping turtle, *Chelydra serpentina*. The foster parent Mute Swans, *Cygnus olor*, moved above the turtle and began to tread water vigorously. The female poked her head and neck deep into the water near where the turtle was located. The turtle released the drowned cygnet.

Key Words: Mute Swan, *Cygnus olor*, Trumpeter Swan cygnet, *Cygnus buccinator*, Snapping Turtle, *Chelydra serpentina*, foster parenting, predation, treading water.

Attacks by Snapping Turtles (*Chelydra serpentina*) on water birds were reported by Coulter (1957) and on Mute Swan cygnets by Willey (1968). The latter reported the loss of 26 cygnets, about a month old, which he attributed to turtles in one pond.

In 1982–84 I conducted studies for the Ontario Ministry of Natural Resources to find out if wild Mute Swans (*Cygnus olor*) could act as foster parents for Trumpeter Swans (*Cygnus buccinator*) in southern Ontario. Trumpeter Swan eggs, close to hatching, were placed in the nests of incubating Mute Swans, whose eggs were removed. After hatching, records were kept on activity to provide time budgets. For 6 hours on most days, and seven times between 19 June and 10 August for 30 consecutive hours, behaviour was recorded for 15 seconds at one-minute intervals.

On 15 June 1984, the first observation of probable Snapping Turtle predation on a Trumpeter cygnet was made at Cranberry Marsh, Ontario (43°50′N, 78°57′W). R. Rieckenberg watched three cygnets feeding with their foster parents Pair E. After 1437 h (EDT) only two were visible, so R. Rieckenberg and D. McLachlin canoed to that brood's range. At 1545 h they saw a white object moving among the emergent vegetation, which proved to be the dead cygnet being eaten by a turtle. The predator left its prey when the canoe was within 1.5 m. The body of the cygnet was still warm and one wing had been consumed. One foot was torn and one toe stripped of its web. There were conspicuous haematomas on the neck and upper breast where the turtle may have initially seized its prey. The cygnet was five days old, and weighed 235 g with one wing missing when it was retrieved.

The second death of a cygnet occurred on 29 June when I was doing time budget observations on Pair G at Cranberry Marsh. The two foster parent Mute Swans and their two Trumpeter cygnets had been feeding as a group for about 7 minutes about 30 m from the blind. They were within 4 m of one another and one cygnet was within 0.5 m of a floating mat of vegetation in an area of deep soupy mud. At about 0802 h this cygnet was seized by a turtle and gradually

pulled under the water. The female immediately moved close to the spot where the cygnet was disappearing and began to tread water vigorously. The male began to utter a series of snorting calls. After 1½ minutes the female stopped treading and moved away. At 0804 h the cygnet's head reappeared above the water. It was still alive. Immediately both foster parents moved to the vicinity of the turtle and both started to tread vigorously. The cygnet disappeared again and the male, still snorting, continued to tread water.

At about 0806 h the turtle let go and the cygnet, covered with mud, floated belly-up to the surface. The pair continued to tread vigorously until 0807 h. The cygnet was clearly dead, its head remained under water and its feet moved weakly. The female swam away about 5 m, then returned and with neck extended looked at the now motionless cygnet. She began to tread water again.

At 0808 h both foster parents poked at the dead cygnet with their beaks. The female then began to poke her head and neck deep into the water. At 0809 h both circled the dead cygnet with the male snorting. At about 0810 h the female swam away about 10 m with the surviving cygnet, but the male remained poking at the body with his beak. At 0812 h the male sat motionless beside the dead bird while the female with her surviving cygnet began to feed. At 0814 h the male assumed the wings-up threat posture and the female returned to the body; although it had now drifted about 2 m from the location where it had drowned, she began to tread water again. At about 0815 h she began to swim away with the surviving cygnet, but turned back and started to tread water again beside the body. She then turned away moving about 3 m but returned again. At 0816 h the male still sat on the water near the body with his wings slightly up. The female swam away but again returned. At about 0817 h she swam away about 10 m, and with the survivor, began to feed. The male drifted slowly away from the dead cygnet and sat on the water with his wings at rest.

At about 0820 h the male swam back to the body and poked at it again with his beak. He remained close until 0826 h and then began to feed. All remained about 10 m from the body until 0839 h when the female again returned to the body and sat on the water nearby. At 0840 h all left the vicinity and moved through the floating mat of vegetation to their loafing spots.

At 0926 h all moved off the loafing spots and returned to the water to feed. At 1008 h the male returned to the dead cygnet, hissed at it and began to tread water again.

The turtle did not try to retrieve the dead cygnet and about noon the body was picked up. There were no marks on its legs and feet and it evidently had been seized by the belly. The cygnet was 15 days old and weighed 912 g when it was killed.

Within the natural range of the Mute Swan in Eurasia, there is no predator comparable to the Snapping Turtle. It does not seem likely that Mute Swans have evolved innate behaviour patterns of defense against turtle attacks in the 26 years (nine generations) that the Ontario population has been feral.

I have seen Mute Swans treading water when feeding on submerged pond weeds, and Trumpeter Swans were recorded doing the same at Delta, Manitoba (de Vos 1964). Trumpeter Swans at the Hennepin County Park Reserve, Minnesota, were seen treading water, presumably when their legs were bumped by fish such as Carp (*Cyprinus carpio*) (L.N. Gillette, personal communication).

An extreme form of treading water is used by captive Trumpeter Swans as a threat display directed at intruding humans (de Vos 1964; personal observation). The bird, with violent foot strokes and much splashing and noise, stands up in the water. I have not seen this display in either wild or captive Mute Swans and cannot find reference in the literature to it in that species.

The water treading by the Mute Swans in the vicinity of the turtle was probably an aggressive pattern, as the male uttered snorting calls similar to those used by territorial males when disputing with other swans or when performing a high intensity threat display (busking) at humans.

The action taken by these foster parent Mute Swans was successful in that release of the cygnet by the turtle was probably due to their water treading. Had they been quicker or luckier in positioning themselves, they might have saved the cygnet.

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Two Adult Male Lapland Longspurs, *Calcarius lapponicus*, Feed the Same Fledgling

JAMES S. SEDINGER

Division of Wildlife and Fisheries Biology, University of California, Davis, California 95616
Present address: Alaska Office of Fish and Wildlife Research and (mailing address) Department of Biology, Fisheries and Wildlife and Institute of Arctic Biology, 211 Irving Building, University of Alaska, Fairbanks, Alaska 99775-1780

Sedinger, James S. 1986. Two adult male Lapland Longspurs, *Calcarius lapponicus*, feed the same fledgling. Canadian Field-Naturalist 100(2): 269–270.

Two adult male Lapland Longspurs (*Calcarius lapponicus*) fed the same fledgling at a pile of bird seed at Old Chevak, Alaska. This probably represented misdirected parental care.

Key Words: Lapland Longspur, *Calcarius lapponicus*, parental care, Alaska.

Lapland Longspurs (*Calcarius lapponicus*) are ubiquitous circumpolar breeders in arctic tundra habitat (Williamson 1968). Few cases of cooperative care of young in this or other arctic-nesting passerines have been reported, but Beyersbergen (1978) observed two female Lapland Longspurs brooding and feeding young from a single nest. Also, Wynne-Edwards (1952) observed three males attending a single nest-building female Lapland Longspur and Alsop (1973) reported that at least two Hoary Redpolls (*Carduelis hornemanni*) assisted with the feeding of young in a single nest. Numerous isolated incidents of similar behaviors have been documented for other birds (see Skutch 1961 for review).

On 15-17 June 1978, I observed (for a total of 3 h) Lapland Longspurs feeding on commercial bird seed at Old Chevak, Alaska (61°N, 165°W), a U.S. Fish and Wildlife Service field station on the Yukon-Kuskokwim Delta (see Mickelson 1975 for a description of the area). Two distinguishable adult males, GL, with a green color band on the left leg and an aluminum U.S.F.W.S. band on the right leg, and ML, with a U.S.F.W.S. metal band on the left leg, used the seed pile. At least one unmarked adult male, two unmarked adult females and two unmarked fledglings also used the seed pile. Between 1200 h and 1330 h on 15 June, GL and at least one unbanded male fed the same fledgling on four and two occasions, respectively. Each feeding session involved the exchange of up to five separate food items. Four of the feeding sessions followed intense solicitation by the fledgling, including calling and wing fluttering. Solicitation was directed toward both GL and an unbanded male. GL defended the seed pile and displaced an unbanded male (once after the unbanded male had fed the fledgling), ML (twice) and a female.

Availability of an artificial food may have attracted birds, thus increasing the density of longspurs locally. If so, my observations might have reflected the response of adult longspurs to an unusual stimulus, begging by young other than their own, and this solicitation led to misdirected parental care.

The fact that Lapland Longspurs have not been demonstrated to possess traits (e.g. high adult survival rate: Custer and Pitelka 1977) commonly associated with cooperative breeding in birds (Brown 1978; Emlen 1978), combined with increased local longspur density, leads me to conclude that my observations probably did not reflect true cooperative care.

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First Record of the Golden Redhorse, *Moxostoma erythrurum*, from the Red River in Manitoba

W. G. FRANZIN,[1] B. R. PARKER,[2] and S. M. HARBICHT[1]

[1]Department of Fisheries and Oceans, Freshwater Institute, 501 University Crescent, Winnipeg, Manitoba R3T 2N6
[2]Department of Zoology, University of Manitoba, Winnipeg, Manitoba R3T 2N2

Franzin, W. G., B. R. Parker, and S. M. Harbicht. 1986. First record of the Golden Redhorse, *Moxostoma erythrurum*, from the Red River in Manitoba. Canadian Field-Naturalist 100(2): 270–271.

Four adult specimens of the Golden Redhorse, *Moxostoma erythrurum*, were collected by gillnet from the Red River near Lockport, Manitoba, about 15 km north of Winnipeg on 9 October 1984. This constitutes a northern extension of the range of this species in the Red River drainage of approximately 350 km and is the first record of Golden Redhorse from Manitoba.

Key Words: Golden Redhorse, *Moxostoma erythrurum*, Manitoba, first record.

Four adult Golden Redhorses (*Moxostoma erythrurum*) were collected by gillnet from the Red River about 1.5 km downstream from St. Andrew's lock and dam near Lockport, Manitoba (approximately 50°05′N, 96°56′W) on 9 October 1984. Two Silver Redhorses (*Moxostoma anisurum*) and six Shorthead Redhorses (*Moxostoma macrolepidotum*) were taken in the same net set along with several White Suckers (*Catostomus commersoni*), three Saugers (*Stizostedion canadense*) and two Walleyes (*Stizostedion vitreum*).

The collection site is slow riverine with a water depth of 3-5 m over a limestone boulder, cobble and gravel substrate. In this area, the Red River has cut through a layer of unconsolidated limestone rubble and clay that overlies the bedrock which is exposed below the tailrace of the St. Andrew's dam. It is a unique and limited substrate in the lower Red River, an area mostly underlain by clay and silt. All three of these species of redhorses are thought to favour, as adults, gravel to boulder substrates of larger rivers (Scott and Crossman 1979) and this may account for their co-occurrence at the collection site.

Collection of all three redhorse species alive and together facilitated easy identification of the Golden Redhorse. Body coloration, dorsal fin shape, fin coloration and lower lip morphology were as described by Scott and Crossman (1979) and easily separated the three species (Table 1).

Golden Redhorses previously have been recorded from both the upper Red River (Jenkins *in* Lee et al. 1980) and a tributary, the Sheyenne River (Peterka 1978), in North Dakota. The only previous record of the species west of Lake Huron in Canada was an unconfirmed report of four individuals by Dechtiar (1972) in a paper on the parasites of forty-one species of fish from the Lake of the Woods area. The specific lake from which Dechtiar obtained the Golden Redhorses was not given.

The confirmation of the Golden Redhorse in the lower Red River is not surprising. Reports from both sport and commercial fishermen of unidentified "different suckers" in this area are relatively common and may indicate not that it is a recent arrival to Manitoba, but rather that it has never been identified correctly. Its occurrence in the lower Red River and the Lake of the Woods area suggests that the Golden Redhorse eventually may be found throughout the Red River, and perhaps in the Winnipeg River, in areas of appropriate habitat.

Acknowledgments

We thank K. W. Stewart for confirmation of our identification and for critically reviewing the

TABLE 1. Some physical characteristics of four Golden Redhorses, one Silver Redhorse, and one Shorthead Redhorse from the lower Red River, Manitoba.

	Dorsal Fin Rays (Range)[1]	Dorsal Fin Shape	Lower Lip Profile	Fork Length (mm)	Weight (g)	Age[2]	Sex
Golden Redhorse	12	emarginate	slightly indented	400	1090	N.D.[3]	N.D.[4]
	14	"	"	337	630	4+	male[5]
	13	"	"	324	550	4+	male[5]
	13 (11-14)	"	"	341	650	4+	male[5]
Silver Redhorse	15 (15-17)	convex	deeply indented	287	390	N.D.	male
Shorthead Redhorse	13 (12-14)	emarginate	straight	345	690	N.D.	N.D.

[1]Range of counts provided by Scott and Crossman (1979).
[2]Age estimated from microscopic examination of thin cross-sections of the first few rays of left pectoral fins.
[3]N.D. — not determined.
[4]ROM 45717, Royal Ontario Museum, Toronto.
[5]Fish Collection, Department of Zoology, University of Manitoba, Winnipeg.

manuscript and Mrs. G. Decterow for typing and word processing.

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Coyote, *Canis latrans*, Preys on Two Bighorn Lambs, *Ovis canadensis*, in Jasper National Park, Alberta

DICK DEKKER

3819 - 112A Street, Edmonton, Alberta T6J 1K4

Dekker, Dick. 1986. Coyote, *Canis latrans*, preys on two Bighorn lambs, *Ovis canadensis*, in Jasper National Park, Alberta. Canadian Field-Naturalist 100(2): 272–273.

In Jasper National Park, Alberta, a Coyote (*Canis latrans*) stalked a lone Bighorn lamb (*Ovis canadensis*) for 25 m, crouched for 10 minutes, and rushed it from 110 m. It seized the lamb by the flank and eventually killed it by holding it by the throat. After attempting in vain to lift and carry the carcass, the Coyote left and attacked a nearby band of four ewes and one lamb. The latter was closely pursued into dense bush and probably captured.

Key Words: Coyote, *Canis latrans*, predation, Bighorn lambs, *Ovis canadensis*, Alberta.

Coyote (*Canis latrans*) predation on Bighorn ewes and lambs (*Ovis canadensis*) in Jasper National Park, mainly during winter, was reported by Bowen (1978) and Holroyd and Van Tighem (1983). To my knowledge, successful attacks by Coyotes on Bighorn lambs have not been documented in detail. This note describes the capture and killing of a lamb, and the possible predation of a second one, twenty minutes later, by the same coyote.

Observation

The incident occurred at Cold Sulphur Springs along the Jasper-Edmonton highway on 25 July 1984, between 1200 and 1300 h. The weather was clear and calm with a temperature of about 25°C. When I first noticed the Coyote, it was walking north along the east side of the highway, just south of the Athabasca bridge. Beyond the bridge, the road was flanked on either side by open shoulders, 15-40 m wide, sparsely overgrown with grasses and flowering plants, mainly sweet clover (*Melilotus* spp.). After crossing the bridge at a fast run, while cars were passing it on the driving lanes, the Coyote walked on the shoulder parallel to the highway for 280 m until it suddenly stopped and froze, looking intently ahead. About 30 m high on a steep shale mountain side, approximately 150 m north of the Coyote, stood a lone Bighorn lamb. It bleated at intervals of 3-10 seconds. No other sheep were in view. After about 10 minutes, the Coyote began to stalk with slow steps, pausing frequently, staring straight ahead and ignoring parked cars and people with cameras on the edge of the road. The Coyote was partly concealed by tall sweet clover plants. Sixty m from the base of the mountain it entered a shallow depression where it was out of view. The lamb, still bleating, inadvertently moved closer to the Coyote by walking about 15 m to a spot where the slope was less steep. The mountainside above the lamb was wooded with mainly White Spruce (*Picea glauca*).

After about 10 minutes, I walked towards the depression until I could see the Coyote, 18 m away. It was crouching, with only its head visible above the grass. It raised itself slightly, but did not appear to be alarmed by my close presence, although I may have triggered its final attack. The Coyote took off and rushed to the lamb, which was 110 m away and reacted quite late. It ran downhill about 10 m and was seized by the left flank. The Coyote held on while the lamb continued to run, turning uphill. The lamb broke free briefly, was seized again, ran downhill and fell on the paved parking lot at the base of the slope, 20 and 65 m away from two picnic tables, respectively, where people were seated, watching the chase. A young woman shouted and threw a stick, whereupon the Coyote let go of the struggling lamb that fled uphill. After the Coyote had run away a few metres, it turned, intercepted the lamb and pursued it closely downhill again. As before, the Coyote seized the lamb by the flank. Held fast by the Coyote, the lamb ran along the base of the slope for about 100 m, crossed the sulphurous stream of water emerging from a vertical cliff adjacent to the shale, and was brought down 15 m farther at the base of the rocks.

I approached slowly, exchanging comments about the incident with the picnickers, who refrained from further interference. I observed the Coyote from 22 m away through 9X binoculars. Making occasional biting motions, the Coyote was holding the lamb by the throat. The prey's spasmodic movements stopped after about five minutes, with the Coyote holding on another five. It attempted to lift the prey as if wanting to drag it away, but was not successful. It then left the lamb and walked to the highway, 25 m away. A passing vehicle caused it to dash back for a moment. After it had crossed the road, the Coyote halted,

screened by sweet clover plants, and looked directly at a group of Bighorn Sheep whose presence I now noticed for the first time. Four ewes and a single lamb were standing on the edge of a dense belt of trees 45 m west of the road and about 60 m from the Coyote. I could not tell whether or not the sheep were aware of the Coyote. While I walked towards it, the Coyote dashed at the group of sheep, which split up and ran to the road, where the four adults reassembled and travelled down the pavement, not to be seen again. The lamb narrowly dodged the Coyote's initial attack and fled into the trees with the Coyote 2-3 m behind. During the next half hour, I made two brief searches of the area but failed to locate either the Coyote or the lamb. The terrain beyond the belt of trees was marshy and overgrown with bushes and tall sedges that probably obscured the Coyote and its prey from my view.

Upon examination, the first kill showed an open wound of about 20 × 20 cm on the left flank. The throat was wet and mangled but not bloody. No autopsy was performed. The lamb's estimated weight was 15 kg. Its size had appeared similar to that of the Coyote when seen together.

Discussion

The four ewes had apparently left one lamb behind on the mountain side while the band had crossed the highway, perhaps to drink. Temporary abandonment and failure to defend their lambs against predators is commonplace among Bighorn Sheep (Geist 1971), although there are reports to the contrary (Shank 1977; Berger 1978).

At Cold Sulphur Springs and other points farther east along the Jasper-Edmonton highway, bands of Bighorns stay most of the year. They accept handouts from tourists, lick salt on the roadbed, and create a serious traffic hazard. These bands are not free from predation pressure; I frequently found the tracks of Wolves (*Canis lupus*) and Coyotes along this section of road. However, their failure to migrate to alpine summer ranges may make these sheep and their lambs more vulnerable to predation than they would be on open highlands, where predators are detected from afar (Geist 1971).

The fact that the Coyote attacked a second lamb right after killing the first is of special interest. Perhaps the Coyote preferred a less exposed location for the carcass, which it had tried to carry away.

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News and Comment

Call for Nominations for the Council of The Ottawa Field-Naturalists' Club

A nominating committee has been chosen by the Council to nominate persons for election to offices and membership of the Council for the year 1987, as required by the Constitution.

We would like to remind Club members that they also may nominate candidates as officers and other members of Council. Such nominations require the signatures of the nominator and seconder, and a statement of willingness to serve in the specified position by the nominee. Nominations should be sent to the Nominating Committee, The Ottawa Field-Naturalists' Club, Post Office Box 3264, Postal Station C, Ottawa, Ontario K1Y 4J5, to arrive no later than 1 December 1986.

The Committee will also consider any suggestions for nominees which members wish to submit to it by 1 December 1986. It would be helpful if some relevant background on the proposed nominees were provided along with the suggested names.

DANIEL F. BRUNTON
Chairman, Nominating Committee

Call for Nominations for The Ottawa Field-Naturalists' Club

Nominations are requested from Club members for the following awards:

Honorary Membership
Member of the Year Award
Service Award
Conservation Award
Anne Hanes Natural History Award

Descriptions of these awards are given in *The Canadian Field-Naturalist* 96(3): 367(1982).

With the exception of Honorary Members, all nominees must be members in good standing.

Nominations and supporting rationale should be submitted no later than 15 December 1986 to

D.F. BRUNTON
Chairman, Awards Committee

Ottawa Field-Naturalists' Club, Post Office Box 3264, Postal Station C, Ottawa, Ontario K1Y 4J5

Baillie Fund Grants 1986: Applications Welcome for 1987

The Trustees of the James L. Baillie Memorial Fund for Bird Research and Preservation were pleased to support six projects in 1986, for a total of $2880.00. Grants were awarded to the Willow Beach Field Naturalists for a bluebird project, to the Saskatchewan Bird Atlas, to Kenneth W. Dance for a study on the status of the Pileated Woodpecker in Ontario 1886-1986, to the Whitefish Point Bird Observatory for a study on staging of Common Loons in the northern Great Lakes, to C. A. Campbell and A. P. Sandilands for the second year of a study of Northern Harriers in Ontario's Luther Marsh, and to the Toronto Ornithological Club for a report on birds in the Toronto area in 1985. The Trustees also decided to provide an additional $500.00 to the Ontario Breeding Bird Atlas to help with part-time employment in winding up the project, with additional support to be considered in the fall. A grant of $150.00 was awarded to the Ottawa Banding Group to help fund a breakfast for visiting ornithologists during the International Ornithological Congress meeting there in June, with a matching contribution expected from the Long Point Bird Observatory.

Applications are welcome for funding in 1987. All projects must be conducted in Canada, and although all types of bird research are eligible for consideration, preference will be given to projects conducted by amateur researchers and to those by professionals who use a high level of amateur participation. Thesis projects and others likely to receive support from other agencies are less likely to receive support than similar quality projects with little or no access to other funding.

All applications must be submitted on forms

available from the Secretary, and should be postmarked by 31 December 1986 to be guaranteed consideration by the Trustees.

The current Board of Trustees consists of Fred Bodsworth (Chairman), Robert Curry, Clive E. Goodwin, Dr. David J. T. Hussell, Dr. David M. Scott, Dr. J. Murray Speirs, and James Woodford. The chief source of funding is the Jim Baillie Birdathon conducted annually by the Long Point Bird Observatory, but direct donations are welcome and tax deductible. A receipt will be issued. Application forms, instructions and further information can be obtained from the address below. Donations should be sent to the same address.

MARTIN K. NICHOLL
Secretary

c/o Long Point Bird Observatory, P.O. Box 160, Port Rowan, Ontario N0E 1M0

Editor's Report for Volume 99 (1985)

There were 136 manuscripts submitted to *The Canadian Field-Naturalist* in the calendar year 1985, a total within the range for the past decade (149 in 1978; 130 in 1984: Editor's Report for 1984: Volume 98, *Canadian Field-Naturalist* 99(2): 271–272). The acceptance total is incomplete but it appears that it will also be comparable to those of recent years.

Volume 99(1) was mailed 22 April 1985, (2) 22 August 1985, (3) 31 December 1985, (4) 11 April 1986. At 586 pages it is the largest volume in the history of the journal, and number 3 at 176 pages is the largest single issue published. Included in 99(3) was the second group of abridged Status Reports for the Subcommittee on Fish and Marine Mammals of the Committee on the Status of Endangered Wildlife in Canada. Publication of these reports was again supported by the Department of Fisheries and Oceans. The sixth contribution to *The Biological Flora of Canada* series appeared in 99(4).

The number of research and observation articles and notes is given in Table 1, the number of book reviews and new titles by topic in Table 2, and the number of published pages by section in Table 3.

A. J. Erskine (birds), C. G. van Zyll de Jong and W. O. Pruitt, Jr. (mammals), C. Jonkel (predator-prey relationships), D. E. McAllister (fish), S. M. Smith (insects), E. L. Bousfield (invertebrates), and C. D. Bird (plants) all continued their active roles as associate editors concerned with papers in their respective fields. Their efforts were supplemented and aided by outside reviewers who have contributed anonymously to the critical evaluation of manuscripts that is vital to the standards of any scientific journal. The following are gratefully acknowledged for their submission of one or more individual reviews during 1985: S. Aiken, J. F. Alex, M. E. Anderson, G. W. Argus, H. Atwood, D. M. Bird, J. S. Bleakney, J. M. Bogart, A. Bouchard, R. J. Brooks, D. F. Brunton, P. W. Ball, L. N. Carbyn, P. M. Catling, J. A. Chapman, A. H. Clarke, W. J. Cody, G. Cooch, R. D. Crawford, T. C. Dauphine, N. G. Dengler, R. D. Dorn, R. J. Douglass, W. H. Drury, E. H. Dunn, D. L. Euler, R. M. Evans, R. Ferguson, S. Forbes, G. Fox, M. W. Fox, P. Frank, A. W. Franzmann, T. D. Galloway, F. F. Gilbert, J. Gilhen, W. Glooschenko, W. E. Godfrey, E. H. Granger, R. H. Green, P. T. Gregory, E. Haber, A. Harestad,

TABLE 1. Number of research and observation manuscripts published in *The Canadian Field-Naturalist* volume 99 (1985) by major field of study.

	Number of manuscripts		
Subject	Articles	Notes	Total
Mammals	20	12	32
Birds	9	8	17
Amphibians and Reptiles	1	1	2
Fish	2	8	10
Invertebrates	4	3	7
Plants	11*	8	19
Other	1	1	2
Total	48†	41	89

*includes one article in *The Biological Flora of Canada* series.
†in addition there were eight COSEWIC articles: one subcommittee update, one status report on a fish and six on marine mammals.

TABLE 2. Number of book reviews and new titles published in the Book Review section of volume 99 by topic.

	Reviews	New Titles
Zoology	38	108
Botany	10	62
Environment	6	78
Miscellaneous	8	26
Young Naturalists	—	58
Total	62	332

TABLE 3. Number of pages published in *The Canadian Field-Naturalist* volume 99 (1985) by section (number of manuscripts in parenthesis).

Issue number	1	2	3	4	Total
Articles	98 (15)	115 (15)	69 (11)	46 (6)	328 (47)
Biological Flora of Canada	— —	— —	— —	16 (1)	16 (1)
Notes	20 (9)	21 (9)	28 (14)	14 (9)	83 (41)
News and Comment	2 (3)	3 (4)	2 (5)	4 (5)	11 (17)
COSEWIC	— —	— —	47 (8)	— —	47 (8)
OFN-C Annual Meeting	— —	— —	10 (1)	— —	10 (1)
Book Reviews	13 (11)	20 (17)	20 (18)	16 (16)	69 (92)
Index	— —	— —	— —	19 (1)	19 (1)
Advice to Contributors	1 (1)	1 (1)	— —	1 (1)	3 (1)
	134	160	176	116	586

C. J. Henny, T. B. Herman, R. Highton, C. E. Hopla, R. R. Ireland, M. L. Johnson, L. Johnson, Z. Kabata, R. H. Kerbes, K. Kershaw, G. L. Kirkland, C. Krebs, P. F. Lee, M. R. Lein, J. Looman, H. G. Lumsden, R. D. MacCulloch, S. D. MacDonald, D. Malloch, R. McKelvey, I. A. McLaren, A. W. Mansfield, J. B. Marliave, A. M. Martell, J. G. Mead, L. D. Mech, H. G. Merriam, G. R. Michener, S. D. Miller, R. D. Montgomerie, P. Mousseau, B. M. Murray, R. W. Nero, M. E. Obbard, L. Oliphant, H. Ouellet, G. R. Parker, D. Parkinson, R. L. Peterson, H. Pough, W. B. Preston, T. E. Quinney, R. R. Ream, R. E. Redmann, A. A. Reznicek, J. D. Rising, J. C. Ritchie, W. Robinson, R. K. Ross, J. S. Rowe, D. A. Russell, M. R. Ryan, J. P. Ryder, A. Sandilands, F. W. Schueler, W.B. Scott, G. W. Scotter, S. G. Sealy, D. E. Sergeant, F. J. Singer, D. Snyder, W. E. Southern, P. Stepney, K. W. Stewart, J. Stewart, I. Stirling, R. P. Thiel, J. A. Thomas, N. A. M. Verbeek, J. Waddington, R. Wassersug, R. D. Weir, N. T. Weiss, W. F. Weller, D. V. Weseloh, K. Wilkinson, R. A. Wishardt, J. Wolff, W. E. Rigley, P. M. Youngman.

George LaRoi continued as Coordinator for *The Biological Flora of Canada* series, E. Wilson Eedy as Book Review Editor, and the unflappable W. J. (Bill) Cody as Business Manager. The meticulous W. Harvey Beck stood patiently by in Alberta to once again compile the Index for the volume.

Recording of manuscripts, acknowledgment of their receipt and mailings and acknowledgments to reviewers and all record keeping have been smoothly processed by Barbara Stewart, and the proof-reading of galleys has been diligently done by Louis L'Arrivée. Thérèse Lapierre has typed correspondence and R. Michael Rankin provided liaison with the printer. Late in 1985, Elizabeth Morton joined the team to assist with editing original and revised manuscripts, and final proofing of type through all stages. Her thoroughness and academic background in English have provided a much needed addition whose full effects should be properly evident in 1986. M.O.M. Printers continued to process the publication of the journal, and as usual we are all indebted to Emil Holst and Eddie Finnigan and the staff there for the attention they have given us.

The National Museum of Natural Sciences continued to allow me partial space and time and R. E. Bedford and the Publications Committee gave support throughout the year. I am also indebted to Joyce for time to work away from the museum, despite the sacrifice of other priorities it has entailed.

FRANCIS R. COOK
Editor

Book Review Editor's Report for Volume 99 (1985)

In 1985, *The Canadian Field-Naturalist* again received a large number (104) of new books for review. Our increasing reputation with these publishers is to the credit of the many hard-working reviewers who contribute to our journal. Of these complimentary copies, 44 had been requested from the publishers while the rest were sent unsolicited. To date, 83 of these books have been sent out to reviewers. In 1985, a total of 75 book reviews were completed, with 62 being published in volume 99. A total of 332 new titles were listed in this volume of our journal.

The number of new books received in 1985 is the

second highest in the past 10 years, while other statistics for this volume are at or above average for the period of record.

New reviewers are always needed. All those interested should send their name along with background on areas of interest to the Book Review Editor. Books can be selected from those marked as available in the New Titles listing. Appropriate titles can also be requested from the publishers. Reviewers must commit themselves to completing a review within two to three months of receiving the book. Guidelines for reviewers are available on request.

WILSON EEDY
Book Review Editor

R.R. 1 Moffat, Ontario L0P 1J0

Errata for *The Canadian Field-Naturalist* 100(1)

Please note the corrections to the following articles:

Peden, Alex E., and **Grant W. Hughes.** 1986. First records, confirmatory records, and range extensions of marine fishes off Canada's west coast. Canadian Field-Naturalist 100(1): 1–14.

The drawings for figures 1 (page 5) and 2 (top of page 6) are reversed — the dark fish is *Aphanopus carbo* and the light one is *Benthodesmus tenuis*.

Fraser, D., J. K. Morton, and **P. Y. Jui.** 1986. Aquatic vascular plants in Sibley Provincial Park in relation to water chemistry and other factors. Canadian Field-Naturalist 100(1): 15–21.

In running head, pages 17, 19 and 21, "FRAZER" should be "FRASER". The table of contents (outside back cover) contains the same error.

Hall, Ivan V., and **Nancy L. Nickerson.** 1986. The Biological Flora of Canada. 7. *Oxycoccus macrocarpus* (Ait.) Pers., Large Cranberry. Canadian Field-Naturalist 100(1): 89–104.

On Figure 3, page 96, the description of condition for plots A and C is reversed. The most vigorous growth occurred at the lowest temperatures.

Under section 7(c), page 97, "abscissic" should be corrected to abscisic [see p. 699 of *Plant Physiology* 81 (1986)].

In Table 1, page 93, the data for *Eleocharis tuberculosa* and *Eriophorum virginicum* should have been listed under column VI rather than column V.

Dermott, R. M., and **C. A. Timmins.** 1986. Occurrence and spawning of Pink Salmon, *Onchorhynchus gorbuscha*, in Lake Ontario tributaries. Canadian Field-Naturalist 100(1): 131–133.

Page 132, right column, line 1: "Liberal" should be Minimal.

Page 133, left column, last line: replace "Ouelett and Côte 1977" with Whoriskey et al. 1981.

Literature Cited: delete Ouelet [*sic*] and Côte 1977 reference and replace at end with

Whoriskey, F. G., R. J. Naiman, and **P. H. Heinermann.** 1981. Steelhead trout (*Salmo gairdneri*) on the North Shore of the Gulf of St. Lawrence, near Sept Iles, Quebec. Canadian Journal of Fisheries and Aquatic Sciences 38(2): 245–246.

Addenda to recent papers in *The Canadian Field-Naturalist*

Chapman, Betty-Ann, J. Paul Goossen, and **Isabel Ohanjanian.** 1985. Occurrences of Black-necked Stilts, *Himantopus mexicanus*, in western Canada. Canadian Field-Naturalist 99(2): 254–257.

A third sighting of Black-necked Stilts has been found for Saskatchewan in 1980, where five birds were seen in August (American Birds 35: 195–196). The status of Black-necked Stilts in Saskatchewan should be changed to occasional spring and summer visitor.

BETTY-ANN CHAPMAN

Department of Biological Sciences, Simon Fraser University, Burnaby, British Columbia V5A 1S6

Received 7 April 1986

Preston, William B. 1986. The Great Plains Toad, *Bufo cognatus*, an addition to the herpetofauna of Manitoba. Canadian Field-Naturalist 100(1): 119–120.

Two additional male *Bufo cognatus* were observed on 28 June 1986, 1.5 km N of Lyleton, Manitoba. Both were calling from a flooded pasture at 2340 h. The air temperature 1 m above the ground was 14.7°C and the water 21.6°C. There had been 1.5 to 2 inches (37-51 mm) of rain the previous night. One specimen was collected (Manitoba Museum of Man and Nature, uncatalogued). Plains Spadefoots, *Scaphiopus bombifrons*, were calling in the distance but not at the same site. Chorus Frogs, *Pseudacris triseriata*, were calling nearby. The following night a single *Bufo cognatus* was calling from the original site.

WILLIAM B. PRESTON

Manitoba Museum of Man and Nature, 190 Rupert Avenue, Winnipeg, Manitoba R2J 1A8

Received 2 July 1986

Tributes to Past Members of The Ottawa Field-Naturalists' Club

The Club has formalized a practice of recording officially special tributes to members who have passed on, and who in their Club careers have made outstanding contributions to Club activities and have notably assisted the Club in attaining its goals.

The first of these tributes, prepared through arrangements by the Awards Committee, was read at the 1984 Soirée by President Frank Pope in honour of Violet Humphreys. It is printed in full below.

A Tribute to VIOLET HUMPHREYS: 1919–1984

Occasionally one is privileged to know an individual who radiates the qualities that characterize field naturalists at their best. Such a one was Violet Humphreys, affectionately known as "Vi" to members of the Ottawa Field-Naturalists' Club.

For almost forty years Violet enriched the natural history community with her unique blend of sparkle, wit, joy, generosity, and good humour. She had a lively interest in many areas of natural history but her special concerns were ornithology, botany, and photography. A keen and knowledgeable naturalist, she was always available to lead field trips and give nature talks, especially for children, beginners, and the handicapped. She was seriously committed to the conservation of our natural heritage and the preservation of the environment. On these issues she held strong views, yet she was tolerant of the opinions of others.

Violet served our organization in many different ways, and always cheerfully and unstintingly. She never sought prestige or preferment. Instead it was her style and custom to serve quietly behind the scenes at necessary but often thankless tasks that brought little public recognition of her contributions to the smooth conduct of Club affairs. Her unfailing willingness to do her share, and more than her share, earned her the special regard of those who had the privilege of working with her on committees and special projects.

Violet Humphreys, an early photograph probably taken when she was employed by National Defense.

Violet Humphreys joined the Ottawa Field-Naturalists' Club in 1946, and subsequently served a total of nineteen years on Council — 1951 to 1961, 1966 to 1968, and 1971 and 1975. Over the years, she gave her constant, dependable support to many Club committees. Among these were Excursions and Lectures Committee, Macoun Field Club, Bird Feeders, Federation of Ontario Naturalists Affairs, Membership, and the Awards Committee. She also devoted many hours to assisting with the Macoun Field Club in its early years. In spite of all these activities, she still found time to contribute articles to *Trail & Landscape*.

Violet was an early proponent and an ardent supporter of the Rideau Trail organization. She was a long-time member of the Federation of Ontario Naturalists, in which she took an active part. She also belonged to the Canadian Nature Federation.

As a member of the staff of the Education Division of the National Museum of Canada, she was for a time involved in nature education with children's groups, and in the care of the National Collection of Nature Photographs. Later, in the Zoology Division, she worked for many years under the direction of Dr. Earl Godfrey, and subsequently under his successor, Dr. Henri Ouellet.

Violet Humpreys' death on 7 January 1984 brought to a close this long and happy association with the naturalist community. Fellow naturalists remember

Vi and Loris S. Russell, then Chief Zoologist, in fourth floor west curatorial area, Victoria Memorial Building, discussing the cataloguing of mammal reference specimens. Note in the lower right the copies of *The Canadian Field-Naturalist*. The upper copy is probably 67(4) October-December 1953, issued 27 November 1953.

gratefully her loyal friendship, the keen enjoyment of natural history that she delighted in sharing with others, and her years of service beyond the call of duty to the Ottawa Field-Naturalists' Club.

BILL GUMMER and the
AWARDS COMMITTEE of the
Ottawa Field-Naturalists' Club

EDITOR'S ADDENDUM

Vi was born 25 August 1919 to William and Ada Humphreys at Ottawa and joined the federal civil service at the end of the 1930s, initially in the Department of National Defense. She moved to the National Museum's Education Division in 1950 and to the Zoology Division in 1952. She was to remain a part of it for nearly 32 years.

Vi shared in the contributions of three scientific generations at the Museum. When she arrived, Clyde L. Patch, the last of the Taverner-Anderson-Patch triumvirate who had kept vertebrate zoology alive at the Museum through the lean years from the First World War to the Second, was winding up his tenure, and Earl Godfrey and Stu MacDonald were already launching the post-war surge in Museum investigations. Henri Ouellet, who had first joined the Museum as a summer student in the 1950s, succeeded Godfrey as Curator of Birds and Chief of Vertebrate Zoology in 1977 after the latter's retirement.

In these changing times Vi was a stabilizing influence. Among other duties, she maintained the detailed literature and distribution records in ornithology according to the system developed by Taverner, catologued collections in birds and mammals, and was responsible for recording all zoology accessions. Her influence was wide, and often felt merely through a well-chosen but quiet comment, or look. More than one new technician, and even the occasional new curator, was never left long in doubt if she felt he or she transgressed Museum traditions. She was an integral member of the select luncheon group which long dissected and influenced Museum views, particularly when this gathering was multidisciplinary and came together daily on the fourth floor of the Victoria Memorial Building in a time when the latter still housed most staff.

Throughout, Vi's museum work was typical of the vital and too often under-recognized contribution made by support staff at all museums. Their painstaking attention to detail and standards assures the fundamental contemporary and future value of the collections as the essential reference library of specimens and data for all systematic and zoogeographical studies and many ecological and behavioural ones.

My thanks to Vi's sister, Mrs. William T. (Grace) Brewer, for providing the photograph, and to her, to Vi's long-time friend Margaret Mitchell, and to Godfrey, MacDonald and Ouellet for their additional contributions.

FRANCIS R. COOK
Editor

A Tribute to BERNARD BOIVIN, 1916-1985

WILLIAM J. CODY and JACQUES CAYOUETTE

Biosystematics Research Centre, Agriculture Canada, Ottawa, Ontario K1A 0C6

On 4 May 1984, members of The Ottawa Field-Naturalists' Club were present at the Annual Soirée at which four individuals were presented with Honorary Memberships. Among these was the eminent Canadian botanist, Bernard Boivin. It is with much regret that we must announce that Bernard Boivin died in Quebec City on 9 May 1985, in his sixty-ninth year, as the result of cancer. Bernard became a member of The Ottawa Field-Naturalists' Club in 1946 and served on the Council from 1950 to 1959. He contributed a number of papers to the Club's journal, *The Canadian Field-Naturalist*, and as recently as 1979 presented a paper to Club members on Canadian botanical history, as a part of our centennial celebrations.

Robert Bernard Boivin was born in Montreal on 7 June 1916, the son of Alexis and Marie Boivin. Bernard, however, dropped the name "Robert" and even the use of the initial "R", because of the confusion with other Robert Boivins, and opted for the name Bernard by which he was known, a name that was not a common one in the Boivin family.

Bernard grew up in Montreal, but a part of his youth was spent in the beautiful nearby region of Charlevoix County, Les Éboulements. It was here that he became acquainted with plants through Father Louis-Marie's *Flore-Manuel*, a book for which he always had a weakness. Indeed it was one of Bernard's goals to produce a new edition of this most useful work, a goal which unfortunately was not achieved. It was in 1932 that Bernard made the first collections for his personal herbarium at Les Éboulements.

Bernard received his B.A. from Collège Sainte-Marie in 1937, and in 1941 his L.Sc. from the University of Montreal, where he was a student of Marie-Victorin, together with Marcel Raymond, Jacques Rousseau and Pierre Dansereau who played significant roles in Canadian botany. A grant from the Province of Quebec (1941-43) gave Bernard the opportunity to study for his Ph.D. at Harvard University under Professor M. L. Fernald. This degree he received in 1944. His thesis, which was written in Latin, was a world-wide monograph of the genus *Thalictrum*.

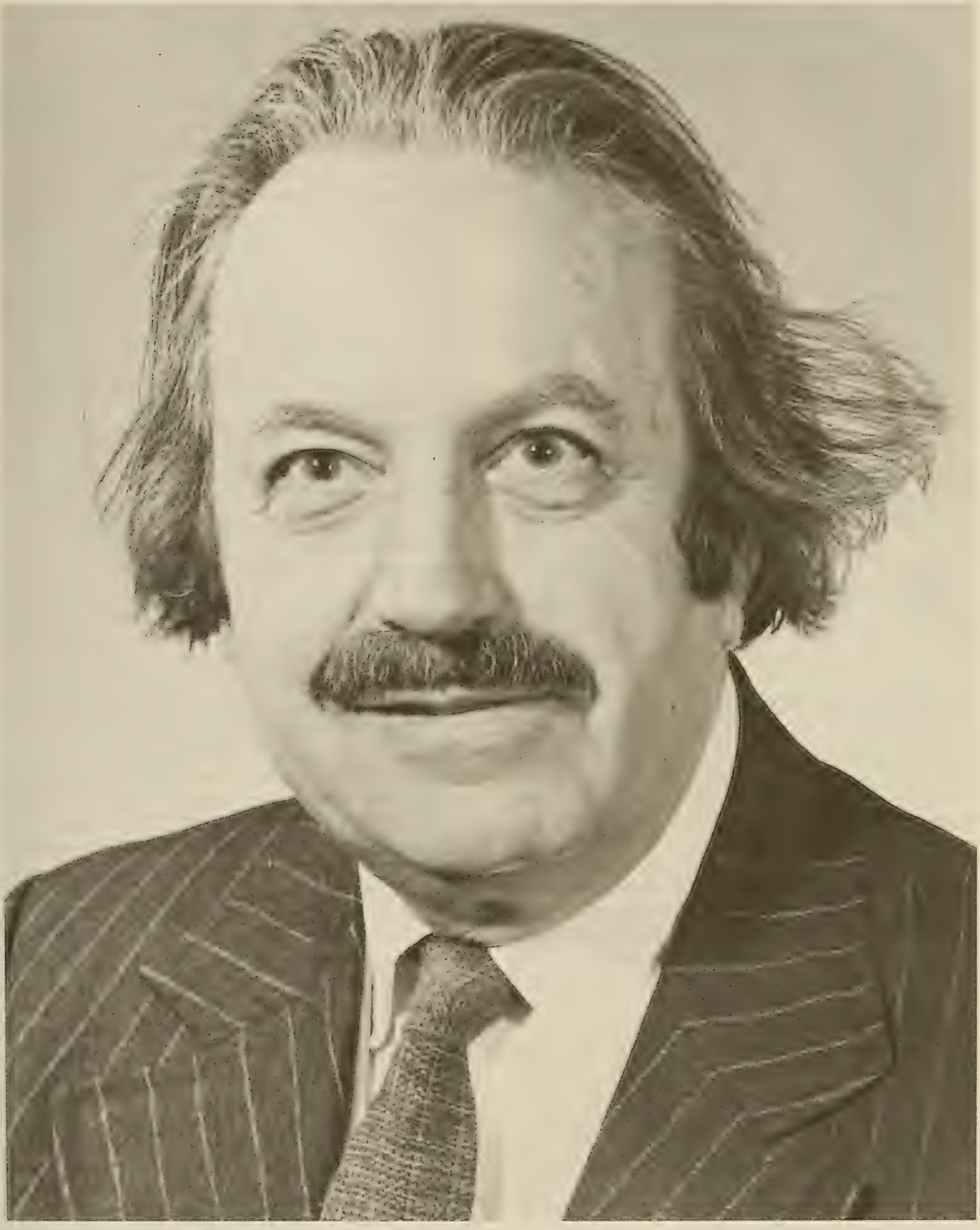
During the latter part of the Second World War, Bernard was attached to the Pacific Division of the Canadian Army, in which he served as a translator and decoder of Japanese. A part of his service was spent in Australia, and it was here while on leave that he wrote a monograph of the Australian genus *Westringia*.

It was Bernard's hope after he received his doctorate that he might join the staff of the Botanical Institute of the University of Montreal. This, however, did not happen. After his war service, Bernard joined the staff of the National Museum of Canada as a botanist (1946-47). It was while working with Erling Porsild that he had his first opportunity to study western Canadian plants in the vicinity of Banff, Alberta. The following year (1947-48) he returned to Harvard University as a Guggenheim Fellow. His studies then were on the genus *Lycopodium*.

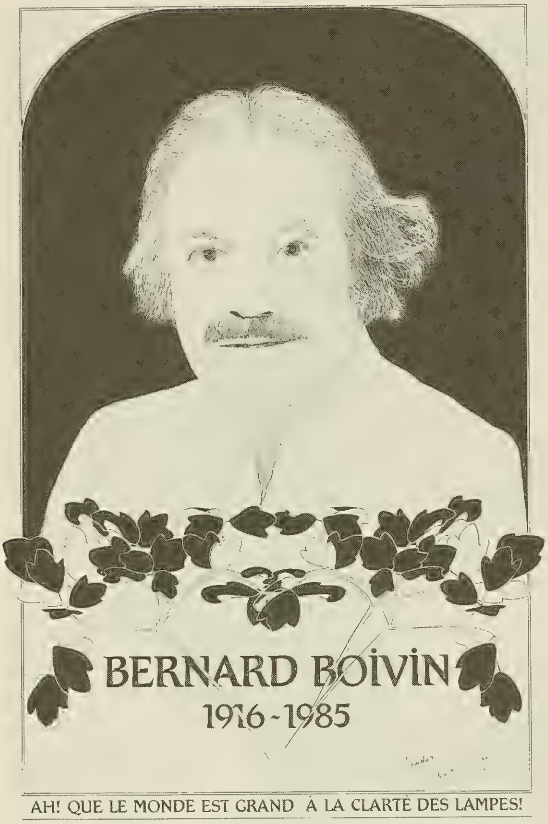
In June 1948, Harold A. Senn brought Bernard to the Botany Unit of the Botany and Plant Pathology Division of Science Service, Department of Agriculture, in Ottawa. He remained there through the name change to Plant Research Institute and later to Biosystematics Research Institute until December 1979 when he transferred to the Department of Agriculture Research Station at Ste-Foy, Quebec. He retired from the Department at the age of 65 in 1981.

Even before Bernard joined the Department of Agriculture he began to accumulate notes on the flora of Canada. His flora of Canada unfortunately was never completed, but he did publish his *Énumération des plantes du Canada* in the journal *Le Naturaliste canadien* (1966-67). This was later brought together in one volume and published in *Provancheria* 6. It was a detailed list by province and territory (including Greenland and Alaska) of his concept of the Canadian flora based on the notes he used for a graduate course he gave at Laval in 1966. No such list had been compiled since John Macoun published his *Catalogue of Canadian Plants* (1883-90). His *Énumération* was both encyclopedic and bibliographic, and contained over 400 taxonomic innovations.

Bernard's field work was conducted mainly in the prairie provinces during the years 1949 to 1960. His *Flora of the Prairie Provinces*, published in 5 volumes (1967-1981), was the culmination of his study of his own collections and those of other botanists who worked in the region. His keys, descriptions and observations were not taken from the work of others but conveyed the whole aspect of the plant concisely,



Bernard Boivin, about 1975. Photograph courtesy of Agriculture Canada, Ottawa.



Scatchboard drawing of Bernard Boivin. The original has been donated by the artist (Marcel Jomphe) to the Hunt Institute for Botanical Documentation, Carnegie-Mellon University, Pittsburgh, Pennsylvania, where it will be preserved in the portrait collection of the archives department.

so that it could be recognized even as a dried, pressed specimen. Frequently he would comment on the possibility of following the treatments of other authors, giving pertinent documentation. Such observations are unfortunately not presented in most modern floras. As in the *Énumération*, there are numerous taxonomic innovations in the *Flora*.

As well as being a classical floristic botanist who worked mainly with herbarium specimens, Bernard had no hesitation in tackling difficult groups of plants. In addition to his monographs of *Thalictrum* and *Westringia*, he published on such groups as Pteridophytes, Compositae, Cyperaceae, Gramineae, *Betula, Potentilla, Rosa, Rubus* and *Oxytropis*. Indeed, in 1956 he published his own concept of the classification of vascular plants (*Les familles des Trachéophytes*). This classification was followed in the *Énumération* and in the *Flora of the Prairie Provinces*.

Bernard's floristic, bibliographic and biographic interests led to the amassing of a file of over 30 000 references, photocopies of over 40 000 specimens selected from over 400 herbaria, as well as information on over 15 000 collectors of botanical specimens. These files are presently housed at the Louis-Marie Herbarium at Laval University. His personal library numbered over 10 000 books and reprints. It was his intention to publish a volume on the collectors of Canadian plant specimens. This unfortunately he did not accomplish. He did, however, publish *Survey of Canadian Herbaria* (1980), a volume which is rich in information about Canadian herbaria, both large and small. His bibliographic works included *A basic bibliography of botanical biography and a proposal for a more elaborate bibliography* (1977a), *The Canadian Field-Naturalist and its predecessors* (1954d) and *Bibliographic survey of James Fletcher's Flora Ottawaensis* (1955d), the latter two in co-operation with W. J. Cody. His interest in the common names of plants is shown in the publication *Quelques noms vernaculaires de plantes du Québec* (1942c and 1943b). In addition, his plans included a 5-part series: 1) Canadian herbaria, 2) Canadian plants in foreign herbaria, 3) Botanists who created these herbaria, 4) Plant collectors of Canadian plants in these herbaria, and 5) Botanical Societies in Canada. Of these, the first was published (1980a) and the last was partly covered in *The Canadian Encyclopedia* (1985a). The others remain as partly finished manuscripts.

Bernard had a passion for books and what could be learned from them. This is borne out by the *ex libris* label he affixed to his books *"Ah! Que le monde est grand à la clarté des lampes!"* (Oh how the world is great in the lamp light) (Figure 1).

In 1965-66 and again in 1969-70, Bernard took leave from his duties with the Department of Agriculture at Ottawa to be a Visiting Professor at Laval University and at the University of Toronto, respectively. After his transfer to Ste-Foy, he was once again associated with students in botany while working in the Louis-Marie Herbarium at Laval University. He enjoyed encouraging both students and amateurs. His lectures on the history of botany in Canada are partly reflected in the recently published *Canadian Encyclopedia* (1985) under the heading "Botany History." Again his interest in botanical history is shown in the *Encyclopedia* and elsewhere in the biographies of eight botanists who worked in Quebec — the earliest and some very recent — Gaultier, Sarrazin, Provancher, Louis-Marie, Raymond, Cinq-Mars, Dutilly and Lepage. Among his students was Camille

Rousseau, whose doctoral thesis, *Géographie floristique du Québec-Labrador* (1974), he directed. This phytogeographic study is without parallel in Canada.

While at Laval University in 1965-66, Bernard, with Lionel Cinq-Mars, was instrumental in the creation of two series of publications of the Louis-Marie Herbarium, *Provancheria* (Memoirs) and *Ludoviciana* (Contributions). His major botanical works appear in these series. He also made a considerable contribution to the reorganization of the Louis-Marie Herbarium at that time.

Colleagues, students and amateurs called upon Bernard for help of all kinds, and this help was given freely. This might be for the identification of a plant, for access to his files on botanical history, biographical information and floristics, for the translation of Latin, or to tap his knowledge of the Code of Botanical Nomenclature. In partial recognition of this help, Dr. Stanley J. Hughes dedicated a new species of fungus *Xenosporium boivinii* to him. Bernard also had a good knowledge of the handwriting of many botanists, both early and present day, a knowledge which was much in demand.

Although Bernard contributed largely to the botany of western Canada and to Canada as a whole, he also did much for the francophone botanical community. This is shown in his regular participation in the ACFAS meetings from 1939 to 1970 and his numerous articles published in *Le Naturaliste canadien*. He was a founding member of the Canadian Botanical Association (1965) and he suggested the foundation of the Société botanique du Québec which began operation in 1980.

Bernard was a nighthawk. His office light might be seen at any time during the night, and indeed it was not an uncommon sight to see him leaving the office as colleagues were arriving in the morning to start the day. As can be imagined, this did not endear him to administrators, but it was during quiet hours that much of his work was done.

Bernard's writing ranged from newspaper articles in his early days to the tomes of his latter years. Throughout his writing he maintained that what he had written should not be changed editorially. This naturally caused problems with editors. He could be persuaded to change a taxonomic opinion, but rarely a word of text. His scientific contributions number over 170 titles. In his bibliography which is appended below, miscellaneous items, conference abstracts and book reviews are included with the scientific papers. When items were reprinted elsewhere, the reprint edition is reported immediately following the original listing. His publications appeared in 36 different journals, in North America, Europe and Australia, in English, French and Latin. It should be noted too, that the Louis-Marie Herbarium proposes to publish several of his studies that were almost complete at the time of his death. In these latter works, Jean-Paul Bernard at the Louis-Marie Herbarium is playing a key role, as he did in the preparation of others of Bernard's larger manuscripts.

In addition to his Honorary Membership in the Ottawa Field-Naturalists' Club, Bernard was named a Fellow of the Royal Society of Canada (1969), and received the Médaille Marie-Victorin (1973) and the Médaille du Centenaire de la Société de Géographie de Québec (1978). Other societies to which he belonged were The New England Botanical Club, Société botanique de France, Saskatchewan Natural History Society, Société botanique du Québec, Josselyn Botanical Society, The International Association for Plant Taxonomy and Association canadienne-française pour l'avancement des sciences (ACFAS).

Bernard was an active philatelist even in the latter days of his life. His botanical activities tapered off in the last few years because of illness, but he still maintained a great interest. In October 1983 he addressed the Société d'animation du Jardin et de l'Institut Botanique (Montreal) on various aspects of Australia including botanical history, flora, vegetation, geography and interesting landmarks, partly based on his experiences there during the war and his return visit in 1981 at the time of the International Botanical Congress, and in June 1984 he participated in the Ontario Field Botanists' foray to Bruce Peninsula.

It was certainly with much sentiment that the Maison Michel-Sarrazin was chosen for him as a place to spend his last days. Bernard in his love of botanical history in 1977 published *La flore du Canada en 1708. Étude d'un manuscrit de Michel Sarrazin et Sébastien Vaillant* and as it turned out, his last publication in 1985 in *The Canadian Encyclopedia* was on Michel Sarrazin, who was the first to collect and catalogue plants in Quebec.

He is survived by his wife Cosette and three children, a son Jacques, and daughters Hélène and Lilian. His death marks the end of an epoch in Canadian botany in which botanists had a broad knowledge of the whole flora. He will be sadly missed.

The help of R. Gauthier, C. Roy, P. Morisset and Cosette Boivin in the preparation of this tribute is much appreciated. The likeness was drawn by Marcel Jomphe from a photograph.

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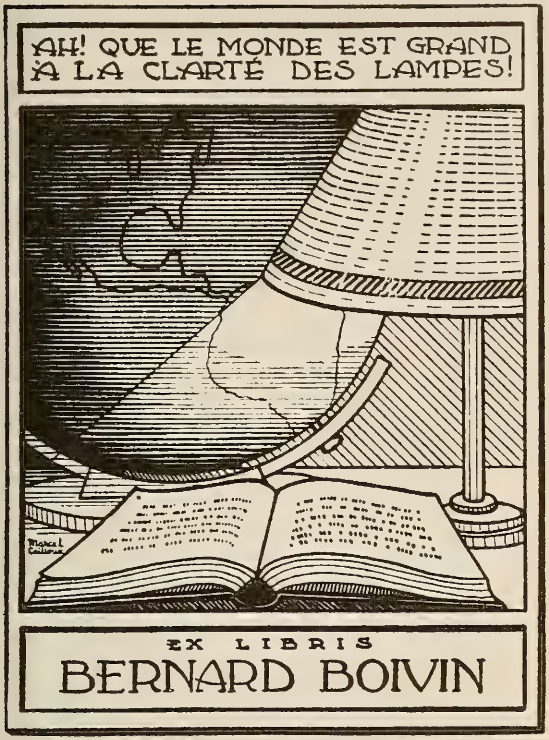

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[and **J.-P. Bernard**]. Flora of the Prairie Provinces. Part VI. Indexes.

Flore du Québec-Labrador et des régions limitrophes. Fascicule I: Cyperaceae.

Flore du Québec-Labrador et des régions limitrophes. Fascicule II: Gramineae.

Salix types in the Barratt Herbarium.

Book Reviews

ZOOLOGY

The Amphibians of British Columbia

By David M. Green and R. Wayne Campbell. 1984. Handbook 45. British Columbia Provincial Museum, Victoria. 101 pp., illus. $3.

I had looked forward to the publication of this new handbook with eagerness for it was the herpetofauna of British Columbia that first stimulated me to pursue a career in herpetology. The earlier handbook by G. Clifford Carl had served me well for many years, but as our knowledge of a fauna increases, updating and revision of such handbooks become necessary.

The amphibian fauna of British Columbia (19 species) represents an interesting and wide variety of adaptations, ranging from those in species such as the Great Basin Spadefoot — restricted in distribution to the arid interior valleys — to those in species such as in the Ensatina of the humid coastal forests. Other species, for example the Long-toed Salamander and the Western Toad, are widespread in the province. The British Columbia fauna proper includes 17 species, since two, the Bullfrog and the Green Frog, have been introduced from the eastern part of the continent. Another species, the Cascades Frog, is illustrated and discussed in this handbook although it has not yet been found in the province. It does, however, occur very close to the border in the State of Washington.

The opening section of the book, 20 pages, introduces amphibians in general, discussing their evolutionary history, adaptations, development, and ecology, as well as their place in folklore, care of captives, where to find them, and suggestions for further research. The introductory section is followed by a checklist of British Columbia amphibians.

Salamanders are introduced next, with a key to the eight species occurring in British Columbia. The species accounts begin with some interesting introductory comments, followed by distinguishing features of the species, and a more detailed description. Habits, breeding, and range are presented as well. Each account is illustrated by an excellent drawing and a spot map.

Frogs and toads are introduced next, with a key to the 11 species known to occur in the province, and the Cascades Frog. The species accounts follow the same format as those for the salamanders.

A glossary is included as well as a list of general references. For a more complete listing the reader is referred to Campbell et al. 1982. [A bibliography of Pacific Northwest herpetology. British Columbia Provincial Museum Heritage Record No. 14.]

I do not hesitate to recommend this handbook to anyone with an interest in the natural history of Canada. The authors are to be commended for this addition to the excellent series of handbooks for which the British Columbia Provincial Museum has long been noted.

WILLIAM B. PRESTON

Curator of Reptiles, Amphibians and Fishes, Manitoba Museum of Man and Nature, 190 Rupert Ave., Winnipeg, Manitoba R3B 0N2

The Birds of Prince Edward County

By R. Terry Sprague and Ron D. Weir. 1984. Second Edition. Kingston Field Naturalists, Kingston, Ontario. xv + 191 pp. $19.

Since the publication of the first edition in 1969, the Kingston Field Naturalists have undertaken a major research project at Prince Edward Point. This volume updates the species accounts to 1983 and makes available the results of the special projects at Prince Edward Point and vicinity.

The introductory pages include a map of the county showing localities mentioned in the text (but no roads or township boundaries), descriptons and black and white photographs of the county and areas of special ornithological interest, and an account of their ornithological work with special emphasis on the Prince Edward Point project.

The species accounts that occupy most of the book include historical information, information on the status at all seasons, average arrival and departure dates, earliest and latest records and dates for high counts, and nest records for breeding species.

The species accounts are supplemented by tables

and graphs in the appendices which give banding totals (including an impressive 3595 Northern Saw-whet Owls), Christmas count results from 1977 to 1983, a check-list of the 318 species known from the county, bar graphs showing their status at all seasons, and special graphs showing somewhat greater detail for the birds of prey.

The work concludes with literature cited, index, and an account of the authors and of the illustrator, Lynn Lougheed, who contributed a few sketches of birds found in the county.

The book is 6 x 9 inches, bound in serviceable heavy gray paper. It will make a handy guide for travellers in the county and a good reference book for your library.

J. MURRAY SPEIRS

1815 Altona Rd., Pickering, Ont. L1V 1M6

Coastal Waders and Wildfowl in Winter

Edited by P. R. Evans, J. D. Goss-Custard, and W. G. Hale, for the British Ornithologists' Union. 1984. Cambridge University Press, Cambridge. 331 pp., illus. £27.50, US $54.50.

Books on the applied ecology of birds remain scarce. This is a good one, well worth the attention of North American readers, though dealing wholly with studies in Europe and North Africa. It originated as a collection of papers read at a meeting of "wader biologists" held in the Netherlands in 1981. Unlike the published proceedings of many meetings, it has been well edited and the brief sectional introductions by the editors are some of the most stimulating parts of the book. The price is substantial but so is the book itself, which is pleasant to look at and to handle. Such encouragements to use can be important, despite the apparent readiness of many scientists to tolerate badly written and poorly produced reports.

European "wader biologists" study shorebirds. Only two of the nineteen chapters deal with wildfowl (ducks, geese and swans). Eighteen of the 35 authors are from the Netherlands, eleven are from the United Kingdom, and the others are from Belgium, Denmark, Sweden and West Germany. All are actively involved in the work being described. One of the most powerful influences on the character and content of the book, R. H. Drent, does not appear as an author, though he took part in the meetings. With the present editors, Drent has been eminently successful in imbuing his collaborators and competitors with the capacity to frame instructive and answerable questions and to devise ingenious practical methods of obtaining quantitative information, without being tempted to play with theoretical constructs that are more elegant than useful.

The three main themes of the book are (1) the influences of food resources on the use of feeding areas, (2) social behaviour and the use of feeding areas, and (3) the significance of specific areas on the Palaearctic-African migration routes of waders. (The third heading conceals the fact that several of the shore bird stocks discussed breed in High Arctic Canada and Greenland.) Most of the chapters deal with detailed investigations of shore bird use of the Wadden Sea, especially in the Netherlands, and of estuaries in England.

There is no substitute for intensive study if the full complexity of resource use is to be appreciated. Though site-specific results cannot be put immediately into North American contexts, many of the ideas drawn up in Europe have already influenced the planning, conduct and analysis of studies in the Bay of Fundy, the Gulf of St. Lawrence, James Bay, and the Fraser Delta. To judge from the absence of references to North American work, west-to-east traffic in ideas has so far been less. In part, this must be due to the fact that no similar compilation of reports on Canadian shore bird ecology has yet been published, although a recent American publication (Shorebirds: Migration and Foraging Behaviour. *Edited by* Joanna Burger and Bori L. Olla. Plenum. 1984) includes (pages 125-202) a major review by R. I. G. Morrison of the Canadian Wildlife Service of "Migration systems of some New World Shorebirds" which is directly comparable to section 3 of this book.

Such awkward technical problems as estimating the rates of turnover, or passage, of birds frequenting an estuary, attempted in several studies, are of great relevance to conservation, as is the correct identification of why these particular species and individuals are using this part of this estuary at this time. If we are so simple-minded and content as to use the maximum number of birds seen as the sole index of use, we may greatly underestimate the importance, and perhaps the indispensability, of particular sites in providing the right food at the right place and the right time in the extensive annual journeying of shore birds. Another important point made in several chapters is that even within a relatively small group of birds of a single species staging or wintering at one site, older

and younger birds may take different foods. Amongst the adults there may be further specialization in preferred locations and foods. All birds are very far from equal and it is a mistake to treat them as units that can be automatically substituted one for another.

One waterfowl chapter deals with the distribution of diving ducks along the southwest coast of Sweden in relation to the availability of benthic molluscs and crustacea and the effects of pollution. The second describes the ways in which Barnacle Geese, *Branta leucopsis*, and European Wigeon, *Anas penelope*, make use of rapidly changing food supplies in the year following the enclosure of many ten thousands of hectares of the Lauwerzee, an estuary in the northern Netherlands, in 1969. These are useful additions to the shorebird studies, helping to remind us that all birds everywhere are continually having to cope with environmental changes, more and more of them influenced by man. Most of the studies reported in this book were funded wholly or in part as contributions to ecological impact assessment, an activity at an even more primitive stage of development than ecology itself. What is particularly encouraging is that most of the work reported has provided credible and informative accounts of resource use, well enough founded and digested to serve as the basis for good advice, even if not necessarily for successful forecasting of the responses of shorebirds to change, a far more difficult task. Given the necessary lead time, applied ecology can be made to work.

HUGH BOYD

Canadian Wildlife Service, Environment Canada, Ottawa, Ontario K1A 0E7

Field Guide to the Birds of North America

By National Geographic Society. 1983. The National Geographic Society, Washington. 464 pp., illus. U.S. $13.95 + U.S. $3.00 postage/handling.

Several field guides have been published during the last 25 years but few, if any, have attained the completeness of the present one. Its 220 full-colour plates depict more than 2400 different plumages of North American birds including a number of vagrants, and represent nearly 800 species. The plates are the work of 13 American artists. The quality of their work is unequal but is in general very good. Most notable are the plates by H. J. Janosik, D. L. Malick, J. P. O'Neill, and H. D. Pratt.

The fact that each artist was assigned a well-defined group of birds does not create great problems in uniformity of style. One of the interesting and useful features of the book is that a number of subspecies and plumages other than the adult plumage (variation due to age, season, sex, hybridization, individual variation, colour morphs, and moults) are depicted. There are a few weaknesses in the illustrations of those plumages, most notably in the loons, gulls, and shorebirds. However, the overall accuracy of the illustrations, which varies from good to excellent, is probably the result of the work of the four expert consultants (E. A. T. Blom, J. L. Dunn, J. P. O'Neill, and G. E. Watson). Colour reproduction of the plates is usually good but in the three copies that I have examined, colour saturation varies from plate to plate and from book to book and tends to be too strong in most cases, thus giving a darker than life appearance to the birds depicted.

How do these illustrations compare with those of the other popular field guides? When compared to R. T. Peterson's *A Field Guide to the Birds*, I found them of nearly as good a quality but perhaps more difficult to use for the beginner. For example, the fall warblers are not all illustrated and when depicted they are placed with the individuals in nuptial plumage of their species. The overall quality is comparable to that of Peterson's guide. However, the present guide has an edge on the latter because all the species expected to be found regularly in North America are illustrated. On the other hand, when compared with Robbins, Brunn, and Zim's *A Guide to the Field Identification of Birds of North America* the scope of the two books is similar, but what distinguishes them at first glance is the superior quality of the illustrations of the National Geographic Society's guide.

Besides the illustrations, which constitute the most important part of any field guide, a text is provided for each species which includes a brief description (the highlights) of the bird, a few words about geographic variation when applicable, a few words about abundance and habitat, a brief description of the voice, and other general details. I found this part very concise and fairly accurate although I would have liked to see more emphasis on differences between similar species rather than just a description. A map giving the breeding and winter (when applicable) ranges and other distributional information is provided for nearly all the species known to breed north of Mexico.

The Introduction contains several useful sections dealing with the scope of the book, the species and families treated, scientific names, plumages, plumage

sequences, field marks, measurements, voice, behaviour, ecology, and range map, and an explanation of the symbols used throughout the book. The short sections on birding, binoculars and telescopes are really too brief to be of much use.

The index includes check-off boxes beside the common name of the species contained in the book which can be used by those who maintain a life list.

The book is well bound with a plasticized waterproof soft cover, which appears to be suitable for intensive field use. The dimensions of the book are slightly larger than those of the other guides available but this does not cause any problem in the field, if you have large pockets.

Overall, this book is the best comprehensive guide to the birds of North America and will be equally useful to beginning and advanced birdwatchers. The price is a bargain and I strongly recommend it to all interested in watching birds.

HENRI OUELLET

National Museum of Natural Sciences, National Museums of Canada, Ottawa, Ontario K1A 0M8

Shorebirds: Breeding Behavior and Populations

Edited by Joanna Burger and Bori L. Olla. 1984. Plenum Press, New York. xv + 437 pp., illus. U.S. $59.50.

Shorebirds have a wide diversity of mating systems and conspicuous migratory habits. These have won them considerable interest from biologists interested in mating systems, population dynamics, migration, and foraging behaviour. This book, the first of two volumes on shorebirds in the *Behavior of Marine Animals* series, contains nine chapters by various authors summarizing selected aspects of shorebird breeding behaviour and population biology. (The second book concerns migration and foraging behaviour.)

The first two chapters are intended as an introduction to both this book and its companion volume. Gochfeld, Burger and Jehl present a taxonomic list of the world's shorebird species, with comments on distribution. This is a good idea, considering the confusing taxonomic history of the group's 217 species. It is intended "to achieve some uniformity of nomenclature for the contributions in this volume" (p. 2). However, there are several instances where the editors have not achieved this consistency. For example, a footnote (p. 2) explains why "Charadriomorpha" is less desirable than "Charadrii" for the suborder that includes plovers, oystercatchers, and allies. Yet in the next chapter, Burger uses both names in the same sentence (p. 71) and "Charadriomorpha" as a heading in a table on the next page. Similarly, Chapter 4 refers to Calidrinae, Gallinagoninae, and Scolopacidae (p. 132) whereas in Chapter 1 the first two are considered tribes, with "-ini" endings, within the subfamily Scolopacinae.

Chapter 2, by Burger, is entitled "Shorebirds as Marine Animals". It is centered on an extensive survey of nesting, migrating, and wintering habitats presented in a 31-page table. Aside from making some taxonomic comparisons, the author does little with these data beyond concluding that most shorebird species make extensive use of marine environments. This is not new to most people familiar with shorebirds, and it was not clear to me that the discussion warranted the amount of space devoted to it.

The following two chapters address aspects of population biology. Evans and Pienkowski present a good mix of theory and data to review population dynamics. An interesting discussion of annual and interspecific variation in survivorship and recruitment reflects the authors' considerable experience with wintering and migrating shorebirds in western Europe. They conclude that evidence for density-dependent population regulation is weak. Oring and Lank take a different approach to population biology, using an interspecific comparison of sandpipers to assess the importance of social systems in the tendency of birds to return to areas where they had hatched or bred previously. This is a well-organized summary which offers a number of interesting ideas. Analyses from the authors' long-term study of Spotted Sandpipers offer further insights into the influence of mating systems on site fidelity.

Four of the remaining five chapters delve further into social systems and breeding behaviour. Lenington examines hypotheses for the evolution of polyandry (females mating with more than one male) in shorebirds. This is a tricky problem that has been the subject of several reviews, including a very insightful and well known Ph.D. thesis by J. W. Erkmann in 1981 which, unfortunately, is not referred to in Lenington's chapter (though it is quoted elsewhere in the book). Using simple mathematical models, Lenington concludes that present hypotheses for the evolution of paternal care (an important prerequisite for the evolution of polyandry) are inadequate. In the next chapter, Miller presents a

broad descriptive survey of communication in breeding shorebirds. He shows that shorebirds have a diverse array of vocalizations and breeding displays which may be quite plastic in their contexts.

Two studies of parental care follow, starting with a discussion by Walters on the evolution of parental behaviour and clutch size. Using his studies of four species of lapwings, he convincingly refutes the notion that parental care in precocial species is a minor problem, and suggests that the costs may in fact limit clutch size. His emphasis on parental care should encourage others to take a second look at this under-studied aspect of reproduction in precocial birds. Nest defence behaviour, a more specific aspect of parental care, is reviewed in the next chapter by Gochfeld. The author notes that "It is difficult to think of another problem where the ratio of anecdotal accounts to scientific studies so nearly approaches infinity" (p. 363). Now the anecdotes are all in one place and they make for very heavy reading — 89 pages divided into eight sections, 37 subsections, and numerous finer headings. Stronger emphasis on evolutionary aspects would have strengthened this synthesis; kin selection and parental investment theory, for example, receive scant attention.

The final chapter, by Senner and Howe, is a timely discussion of conservation of nearctic shorebirds. Using a map and accompanying table, they present an important summary of 58 major stopover sites for migrant shorebirds, and consider threats to populations, legal bases of protection, and criteria for monitoring populations.

The editing of this volume could have been stronger. In addition to problems of uniform taxonomy noted above, there are a number of minor inconsistencies and errors, some of which are rather surprising. For example, the scientific name of Pectoral Sandpiper is given as *Calidris melanotus* five times and *C. melanotos* three times (the latter is correct). *Phalaropus lobatus* is called Northern Phalarope four times and Red-necked Phalarope six times (the latter is more recent). In the references for Chapter 7, only the first page number of each entry is given; the other chapters give the first and last. The rates of return to the breeding grounds of Temminck's Stints and Dunlin cited in Chapter 3 (p. 94) differ from those in Chapter 4 (p. 128). A photograph taken by Burger, printed on page 314 of Gochfeld's chapter, shows a Red Phalarope at Churchill, Manitoba, "injury feigning" on the water. There are no confirmed breeding records of Red Phalaropes at Churchill; they migrate through the area en route to more northerly nesting grounds. Furthermore, the bird shown is a female, yet as Gochfeld notes on p. 340, males perform "most or all" nest protection behaviour. The bird is actually *bathing* in the rocking manner typical of phalaropes.

Despite these errors, the book contains a number of well-written chapters that will be useful to those interested in shorebirds themselves, and in avian breeding behaviour in general. The heterogeneous mix of topics addressed reflects the broad front that recent shorebird research has taken. People interested in buying the second volume as well may find the combined price (U.S. $89.50) tolerable. However, the high price of the present volume (Cdn. $81.50), its spotty editing, and somewhat variable quality of its component chapters render the whole somewhat less than the sum of its parts.

JOHN D. REYNOLDS

Department of Biology, Queen's University, Kingston, Ontario, Canada K7L 3N6. Present address: Department of Biological Sciences, Simon Fraser University, Burnaby, British Columbia V5A 1S6

Woodpeckers of the World

By Lester L. Short. 1982. Delaware Museum of Natural History, Monograph Series Number 4. Greenville, Delaware. xvi + 676 pp., illus. U.S. $99.95.

A number of monographs on groups of species, on families, even on orders, have been published during the last 25 years but one on woodpeckers has not appeared since the publication of Malherbe's *Monographie des Picidées* in 1861-1862. The present work, as stated by the author, is the culmination of his research efforts over 20 years, with the result that an enormous amount of information is contained in this large attractive book.

In the introduction the author briefly describes the contents and defines a number of terms which he will use in the text. Drawings would have been very useful here, particularly for the definitions of "feathers" and "external parts," which are difficult to understand unless one is already familiar with ornithological terminology. In the next section, "Plumage and Structure", he discusses such topics as colour patterns, sexual dimorphism, and moult and adaptations, to name only a few. A section on behaviour follows in which numerous topics are dealt with in less than a dozen pages. "Zoogeography,

Evolution and Systematics" occupies the next 20 pages and gives a good overview of these topics as they relate to woodpeckers, although one would have liked to have had more about most of these topics. It is in this section that the author provides a classification of the woodpeckers of the world which reflects entirely his own views and where he used the superspecies concept liberally — perhaps too liberally. He recognizes 198 species and concludes this important section by expressing well-justified concerns about the future of several species which appear to be threatened in several parts of the world. This threat is becoming greater each year as vast areas of mature forests are regularly destroyed everywhere.

A short diagnosis is given for the genera and, in addition to the morphological characteristics, includes ecological, behavioural and zoogeographical information. Each species is treated in approximately 2.5 pages and the following sections are given: range summary, diagnostic features, description, distribution and habitat, foraging habits, voice, displays, interspecific interactions, breeding, taxonomy, and references. As one can see, the book deals heavily with ecology and behaviour. The author has drawn considerably from this information for his taxonomic conclusions and these may not be acceptable to all, particularly at the generic level. At the subspecific level, the author gives good summaries of zoogeographic variation, although certain of his conclusions indicate a strong tendency towards "lumping". In all those sections, the most notable shortcoming is the lack of range maps. These would have made the book much more useful and would have contributed to a better understanding of distribution problems and of how distribution patterns do or do not intermesh with each other.

The 101 plates by George Sandstrom are very good and depict each species in detail. Even though the artist often tends to stylize the subject, in this case the approach produces excellent results. The artist has demonstrated a good ability in depicting birds in natural postures and in showing their characteristics without giving the impression that one is using a field guide. The reproduction of the plates is generally good although a number of them tend to be dark, at least in the three copies that I have examined. The book is attractively bound in a very appropriate wood-grained solid cover.

In conclusion, both the author and the artist deserve well-earned congratulations for their good work. In spite of its relatively high price, I strongly recommend this monograph to anyone interested in woodpeckers.

HENRI OUELLET

National Museum of Natural Sciences, Ottawa, Ontario K1A 0M8

The Birds of China

By Rodolphe Meyer de Schauensee. 1984. Smithsonian Institution Press, Washington. 600 pp., illus. U.S. $42.00

Recently there has been an inundation of new and revised North American field guides. These have been expertly reviewed in minute detail. *The Birds of China* does not need to be reviewed in such a fashion. The best that most of us can hope for is a brief three-week visit to this fabulous country. In so short a time we can expect to see only a handful of the more common birds, even if we go with a tour. *The Birds of China* will be more than adequate as a field guide under these circumstances.

The book covers all of the 1195 species known to occur in China. Each has a species account with a brief description of the appropriate plumage, followed by an account of the bird's range. There are maps on both end papers that give the locations of the major geographical and political features mentioned in the range description. The text is in English.

About half of the species are illustrated in the colour plates, with another 50 or so species covered by Kleinbaum's excellent black and white drawings. In general, the plates are well done, although I find Dick's habit of outlining in black a bit too cartoon-like for my taste. Gwynne's work is more artistic, while Trimm's plates look like paintings of museum specimens (which is what they are). The birds not illustrated tend to be those covered by other Asian or European guides. For example, most of the gulls and shorebirds are not illustrated.

The species descriptions are rather brief, but that is understandable in a book of this size. I would have preferred to have had more help with understanding the birds' range. Small range maps like those used by the Golden guides would have been very helpful. It is difficult to translate the written range description onto the end paper maps, especially if you are not familiar with China's geography. Even a biogeographic map would help.

There is an excellent brief description of China's geology and a fascinating account of the history of Chinese archeology.

Although the book was not scrutinized for errors, few were found. One was noticed on plate 12, p. 62, where the names for birds number 11 and 12 were switched.

This book is of course a mandatory purchase for visitors to China. But it is also good value to collectors of bird books. If you can afford it, buy it and dream a little!

ROY D. JOHN

National Uranium Tailings Program, Energy, Mines, and Resources Canada, 455 Booth Street, Ottawa, Ontario K1A 0G1

Reproductive Decisions: An Economic Analysis of Gelada Baboon Social Strategies

By R. I. M. Dunbar. 1984. Princeton University Press, Princeton. 265 + 10 pp. U.S. $40.00 cloth, $14.50 paper.

At high altitudes in Ethiopia, Gelada Baboons live in complex societies. In this book Dunbar draws together the results of his extensive field studies on this intriguing animal by synthesizing the data in terms of quantitative models. Within an adaptationist framework which assumes that animals have evolved behavioural decision rules which maximize reproductive success, he focuses on reproductive strategies, their proximate causation, and their relative efficiencies. Following a general introduction to these strategies and the analytical approach of multivariate dynamic models to be used, Dunbar provides five chapters of background to the topic. Gelada populations are hierarchically structured from reproductive units dominated by a single male through teams and bands to herds, along with all-male groups. The predominately grass diet provides ecological constraints on morphology, feeding, and movements. The demographic processes, such as survivorship, fecundity, and migration, are detailed for the population. Socially, the units are structurally stabilized through interacting female pairs and linear dominance hierarchies. Dominance rank and oestrus act as constraints on female reproduction.

The next three chapters deal with the reproductive problems facing females. Coalitions with other members in the unit are important for the inclusive fitness of females, and Dunbar shows why coalitions with relatives are desirable, why the male is a poor partner for a coalition, and why deserting the unit is a last resort. These reproductive strategies are modelled and the resulting predictions tested. Within the strategies females have a variety of tactical options which include behaviour (such as cues signalling oestrus), reproduction (inter-birth intervals), and parental investment (nursing).

The reproductive complexities confronting males are discussed in the next six chapters. A male must ensure the loyalty of his group members. This becomes an increasingly difficult task as the group grows larger, and harem size is stabilized by fission. Harem acquisition is treated as a set of alternatives embedded in a flow diagram of decisions. The costs, benefits, and constraints of these male reproductive strategies are interpreted in an economic model. Male tactics include, for acquisitive males, choice of harem size at takeover and, for defending males, responses to challengers. The strategic analysis is extended to encompass social and environmental factors and other problems such as old males staying with a group. The book concludes with a general consideration of conflicting interests in an evolutionary context, including reflections on methodology and animal consciousness.

Data, hypotheses, tests, and interpretations are well presented in the clearly written and crisply organized text accompanied by good illustrations. The results from the models are compared with data from the author and others, although no comparison with other primate species is attempted. The inclusion of sensitivity analyses, to see the extent to which output is changed by variation in the values of the parameters of a model, is laudable, as is the use of different measures to assess the association between, say, social relations and size of the unit. Dunbar's work exemplifies the development of field studies of social systems from descriptions to analytical investigations involving hypothesis testing and model building. Good instances of this are the examinations of why the linearity of the dominance hierarchies decreases in larger harems, and how males deal with loyalty problems in their units. Dunbar is motivated to discover cognitive rules of social behaviour which reflect universal biological principles. The resulting attempt, which employs a variety of quantitative tools from Bessel's formula to the theory of evolutionarily stable strategies, foreshadows the shape of studies to come. The many who share Dunbar's aspirations will rejoice in this volume.

PATRICK COLGAN

Biology Department, Queen's University at Kingston, Ontario K7L 3N6

Current Ornithology — Volume 2

Edited by Richard F. Johnston. 1985. Plenum Press, New York. 364 pp. U.S. $39.50.

As Johnston says in the Preface, ornithologists since 1949 "have tended to become ever more professional in their pursuits and to incorporate protocols of experimental biology into their work," allowing "conclusions unmarred by wishful thinking." Not surprisingly, much of the new science is of less interest to the general public than were the writings of museum ornithologists and professors of an earlier era.

This book consists of nine review articles. Frances James and Charles McCulloch describe data analysis and the design of experiments in ornithology. They deplore "too many untestable speculative hypotheses and too many instances of misapplied inference," and "many premature and even inappropriate statistical tests." They give understandable examples of theoretic models, with some illustrative field experiments. For example, male Long-tailed Widowbirds have increased mating success if an abnormally elongated tail is experimentally spliced on, but greatly decreased success if their tails are shortened.

Helmut Mueller and Kenneth Meyer, in a most interesting study, examine 14 hypotheses offered to explain why female raptors are larger than the males. Their conclusion: to facilitate female dominance, thus reducing the risk of injury to the female.

George Barrowclough, Ned Johnson, and Robert Zink using electrophoretic frequency of alleles, discuss the nature of genic variation in birds. Patterns are consistent with the mutation-drift theory, variation occurring by chance, and "neutral" as regards species fitness. They found no evidence of Darwinian selection for fitness.

Robert J. Raikow provides a brilliant explanation as to why experts disagree so often on avian classification — "it passeth all understanding." Classification, a more narrowly defined field than systematics, is the study of diversity. There are three schools: the traditional, eclectic or "evolutionary" school; the phenetic, numerical taxonomic school which studies similarities; the cladistic or phylogenetic school which studies genealogies. Raikow clearly favours the last. The ultimate check-list, he hopes, will use both morphological and DNA hybridization data to produce a classification that will express phylogeny.

Bernd Leisler and Hans Winkler studied relationships between behaviour and such morphological attributes as decreased body size, aspect ratio, and long rectal bristles among fly-catching birds. Jared-Verner discusses the shortcomings of virtually all methods of conducting censuses for free living birds.

There are also articles on vocal "dialects" in Nuttall's White-Crowned Sparrows by Kroodsma, Baker, Baptista, and Petrinovich, on syringeal structure and avian phonation by Abbot and Sandra Gaunt, and on circadian organization of the avian annual cycle by Meier and Russo.

Both James and Verner, refreshingly honest, point out imperfections in their own earlier studies. Few ornithologists will be interested in all articles but any serious student should find several of interest and value. Borrow a copy from your nearest university library.

C. STUART HOUSTON

863 University Drive, Saskatoon, Saskatchewan, S7N 0J8

The Ecological Implications of Body Size

By Robert Henry Peters. 1983. Cambridge University Press. xii + 329 pp.

Scaling: Why is Animal Size So Important?

By Knut Schmidt-Nielson. 1984. Cambridge University Press. xi + 241 pp.

All too often, in reading or reviewing natural history studies, one encounters statements of the form "*Xus yus* thus exhibits a significantly larger home range than *Zus zus*," in a context which makes one want to wring the author's neck and utter statements of the form "But you just showed that *Xus yus* is two and a half times as big as *Zus zus*: what do you expect them to do: sulk in their burrows and starve for want of forage?" The allometric differences between organisms are well understood in terms of physical laws, and account for more of the differences among organisms than any factor other than the most fundamental taxonomic divisions, but all too often they are neglected in comparisons of related species. No biologist, having read either of these volumes, should be able to compare organisms of differing body size except as (explicitly or by implication) the residuals from the differences expected on the basis of their sizes alone.

Peters approaches the problem of developing a predictive ecology by using multiple regression in a hypothetico-deductive program: the ecologist's job is to construct falsifiable predictive hypotheses and to find how well they are corroborated by data. The measure of corroboration is how much of the variation of dependent variables the hypotheses can explain when they are translated into the ritual language of multivariate statistics. This approach is characteristic of University of Toronto zoology graduates, and body size is certainly the finest independent variable for it, since size is easily measured on any organism for which any dependent variable is known. Size is such a compelling independent variable that others are rarely reported in Peters' sources. He cannot implement the multivariate aspect of his program, and is largely restricted to comparing the slopes of univariate regressions to find the gross scaling of ecological parameters to body size.

His book is an attempt to see how much of ecology can be explained by animal size as an independent variable — or, to look on the other hand, how well ecological parameters can be predicted from size alone. It is organized by the components of the "balanced growth equation" — the inputs and outputs of energy and material through an individual or population. After introductions to allometric scaling, hypothetico-deductive philosophy, and the statistics of regression, it treats, in this framework, respiration, circulation, temperature, locomotion, ingestion, production, mass flow, animal abundance, behaviour, ecological economics, and evolution. In most cases the results are too preliminary to be individually evaluated: "One might allow scientists a certain disinclination toward the quantitative study of defecation. However, when one considers the vast range of disgusting phenomena that have been examined . . . this lacuna is less forgivable" (p. 151). The text closes with discussions of the unclear causes of physiological allometry, the use of simulation to study its effects, and the need for more and better data, but it is followed by 61 pages of appendices listing hundreds of physiological allometric relationships, all translated into uniform SI units.

A number of problems exist in Peters' book. Darcy Thompson's *On Growth and Form* is dated from the 1961 reprint, rather than from the original editions, Eviator Nevo becomes N. Eviator on p. 157, and the abominable paraphyletic expression "herptiles" appears on p. 169. More serious problems are the paucity of botanical, growth, and morphological relationships. The author of a prospective review is limited by the data that have been gathered for other reasons, but there must be some botanical allometry, and the comparison of intraspecific allometry (due to growth) with interspecific allometry (in adult size) must be important for establishing the generality of the importance of size alone as an ecological factor. Peters also does not deal with the size-based ecology most familiar to me, the allometry of feeding structures and the sizes of closely related sympatric species.

Schmidt-Nielson's book is a general introduction to allometry. Its thrust is towards the mechanical and physiological reasons for allometric relationships in physiological and evolutionary time rather than Peters' intermediate time scale and community scope. The ideas fall together smoothly, and the topics dealt with are well-studied: bird's egg size, skeletal strength, metabolic rates, homeothermy, tissue-specific metabolic rates, respiration and circulation, the meaning of time, metabolic scope, locomotion, and thermoregulation. The stories are told with a cheerful certainty that belies the ambiguity of many of the conclusions — the discussion of dinosaur homeothermy, for example, drifts into inconclusion with the citation of an equally inconclusive symposium — but it is heartening to see stories of interspecific differences told with so much of the variation accounted for, and with such a close relationship to physical causes.

There is so much complexity and so many unknowable causes in the subject matter of natural history and systematics that it is important to realize that there are strong regularities in these fields if they are viewed from different perspectives, and to incorporate these points of view into general natural history and systematics. Schmidt-Neilson reviews the physiological allometric perspective, while Peters elaborates a comprehensive ecological allometry that may lead to a newly quantitative approach to the patterning of species in communities.

FREDERICK W. SCHUELER

Herpetology Section, National Museum of Natural Sciences, Ottawa, Ontario K1A 0M8

The Puffin

By M. P. Harris. 1984. T. & A. D. Poyser, Calton, Great Britain. 224 pp., illus. £12.60.

A wonderful bird is the puffin. That ought to be the opening line of a limerick, and I only wish it was. Nobody but Edward Lear could do full justice to the puffin's enormous and many-splendoured beak, its clownish face, and its Monty-Pythonesque repertoire of silly walks. Ronald Lockley caught some of these bizarre qualities in his book *Puffins*, a pioneer scientific study which is also a chronicle of the lives of a pair of birds, "Frater" and "Cula", on Skokholm Island off the coast of Wales. Mike Harris is Lockley's successor — indeed, he may even have banded some of Frater and Cula's great-great-grandpuffins in the course of his fieldwork in Wales. His book summarizes some 15 years of recent research on puffins, mainly in the British Isles, by himself and others. His approach is properly scientific — he considers it complementary to Lockley's classic. Even so, he can't conceal his fascination with this odd little seabird.

Harris' approach is thorough, although sometimes a little abrupt. He begins with the position of the Atlantic Puffin *Fratercula arctica* in the family Alcidae as a whole, and goes on to discuss the bird's morphology and distribution, the problem of counting puffins in their colonies, breeding biology, food, the growth of the chicks, predators (including man), population dynamics, and the little that is known of the puffin's life at sea. Kenneth Taylor has contributed a chapter on courtship and aggressive behaviour. The book is illustrated by a not very inspiring collection of photographs, but these are more than redeemed by Keith Brockie's drawings.

I can only give a few highlights in this review. Harris suggests, "with some trepidation," that the world population of the puffin is in the order of 15 million birds; perhaps 10 million breed in Iceland, while our own share — mainly in Witless Bay, Newfoundland — is half a million or less. He puts more emphasis than I like on the role of climatic, as opposed to oceanographic, factors in determining puffin distributions — but I may be unfair here; we know so little about their lives at sea. (The irritating little birds *dive*, instead of taking off, at the approach of a ship, and are virtually invisible in all but the calmest conditions.) His contention that predation and kleptoparasitism by Herring Gulls are *not* serious causes of chick mortality will raise at least one pair of eyebrows in Atlantic Canada. We will have to forget a few cherished myths: adult puffins don't abandon their young before these can fledge; nor do they feed them on loads of fish neatly arranged across the bill, heads alternating with tails.

The chapter on puffins as a part of human diet may seem distasteful to anyone who hasn't actually eaten them. Hunting seabirds has always been important in Scandinavian countries, and persists to this day as a carefully regulated harvest in Iceland and Faeroe. It's odd to reflect that in mediaeval Iceland, this type of food was specifically reserved for the poorest inhabitants who, for the purposes of ecclesiastical fast-days, were allowed to consider it as fish. The enormous numbers of puffins in Iceland today is evidence of the Icelanders' instinctive feeling for conservation and management. Our own record, I'm ashamed to say, is nothing short of disgraceful. During the 19th century puffins were hunted almost to extinction for their flesh and feathers at many North American colonies, and the slaughter continues even today along the north shore of the Gulf of St. Lawrence. Yet puffins have nominally enjoyed complete legal protection in Canada since 1917.

Finally, Harris draws attention to a more insidious human influence on puffin populations. Now that we have overfished many of the stocks of traditional food-fish, we are turning to the smaller species which are central to the food-webs of seabirds. He notes that the biggest puffin colony in Norway has had only two successful breeding seasons between 1970-83. The chicks died of starvation in the other years, possibly because of the overfishing of herring, the principal food. The Canadian equivalent is the intensive fishery for capelin off Newfoundland, which began in 1970, and had to be partially closed in 1978. Our Newfoundland puffins apparently have no suitable alternative prey, and the omens for their future are not particularly propitious.

This isn't the last word on puffins. I look forward to an equally thorough treatment of the Canadian research which has been going on since the 1960s. But Harris' book is an important study, and essential reading for any serious student of seabirds.

R. G. B. BROWN

Canadian Wildlife Service, Bedford Institute of Oceanography, P.O. Box 1006, Dartmouth, Nova Scotia B2Y 4A2

American Insects: A Handbook of the Insects of America North of Mexico

Ross H. Arnett Jr. 1985. Van Nostrand Reinhold Company, New York. xiii + 850 pp., illus. U.S. $79.50.

This book is a reference guide to the insects of America north of Mexico. It is divided into two parts. Part I is composed of six chapters. The first five serve as an introduction to the book itself, and to insect classification, identification, biology, ecology, and distribution, and describe methods for collection, preservation, and study. The sixth chapter provides keys to the orders of all extant and extinct orders of insects. Keys are provided to larvae and pupae of extant holometabolous orders as well.

Part II comprises the bulk of the book and is composed of a complete listing of every order and family of insects known from the study area. These are arranged according to the prevailing, generally accepted classification scheme recognized by various authorities on different groups. Keys are provided to families, and, in some cases, to subfamilies, or genera. Every genus known to occur in Canada and the United States is listed under the appropriate family, subfamily, or tribe with the number of described species, and, for many, their general distribution. Over 7700 species are listed with authors and common names. The most important, widespread, or distinctive species, particularly the medically and economically important ones, are briefly described. Comments on aspects of the habitat, behavior, or biology are included from many species and higher taxa. There are over 1200 line drawings and black and white photographs of insects illustrating the common, important, and representative species. At the end of each order is a short bibliography of important works for further study of the North American fauna.

This book is designed to provide handy descriptions of common and important species that are sufficiently detailed to permit identifications by non-specialists. It is also an aim of the author to be as complete as possible in accounting for every species in Canada and the United States by listing the number of species in each genus known from these areas. On this latter point, I am sure that Professor Arnett has been very thorough and quite successful. However, on the former point, the descriptions of species are insufficiently detailed to allow non-specialists to accurately identify any other than the larger and more conspicuous species. Furthermore, the keys are not illustrated, making them difficult to use for any other than well-trained taxonomists. One additional difficulty is that there are no captions for most figures in Part II. Therefore, to learn which species is illustrated one has to hunt for the reference to the figure in the text. Also, frequent reference is made to photographs in the author's field guide (R. H. Arnett Jr., and R. L. Jacques Jr. 1981. *Simon and Schuster's Guide to the Insects*. Simon and Schuster, New York. 511 pp. U.S. $9.95). Having this field guide available makes the handbook much more successful.

There are textbooks of entomology that provide more in-depth treatments of insect biology and ecology, and one of the standard texts also includes well illustrated keys to all the North American families and keys to the subfamilies of many. Field guides, such as the author's, generally have better illustrations than the small figures in this large (8½"x11") volume. For students and amateurs I don't recommend the investment necessary to buy *American Insects*. However, for professionals faced with the task of providing identifications of a large and diverse fauna, no other single source provides such a complete listing of all North American genera. Pest control operators, agricultural consultants and extension agents, university professors, and museum curators will find it a useful and convenient resource.

CHARLES R. PARKER

8256 Getty Court, Springfield, Virginia 22153

Wood Warblers' World

By Hal H. Harrison. 1984. Simon and Schuster, New York. 336 pp., illus. U.S. $19.95.

Wood Warblers' World can best be described as a series of splendidly illustrated essays on the 53 species of Wood Warblers (Parulinae) known to nest in Canada and the U.S.A. One species, the Rufous-capped Warbler, is included on the basis of one nest record in Arizona, with a subsequent suspected nesting and a few other occurrences. The Olive Warbler, considered by some ornithologists to be more closely related to chickadees (Paridae) is included, in keeping with current placement by the American Ornithologists' Union. Species accounts range from three to eight pages, each containing a map of breeding range in North America and one or more black and white photographs. All but two

species (Tropical Parula and Rufous-capped Warbler) are also illustrated by colour photographs on 24 plates grouped in three sections in the midst of the text. The text also includes a foreword by Les Line, a brief introduction, a glossary, and an index.

The dust jacket designation of the species accounts as "comprehensive life histories" is misleading. The author has consulted the literature extensively and in addition to his own experiences uses published information in each account. However, none of the accounts can be described as comprehensive, and emphasis varies from one account to another. Favoured topics include nests, nesting habitat, food, history of the discovery and/or the name of the species, and song. Harrison seems to be especially interested in song variation, yet does not mention the descending trill of the Northern Parula described by Taylor, Koes, and Neily in Manitoba (McNicholl and Taylor 1982, Blue Jay 40:109-119) or the three-part song of the Townsend's Warbler in parts of British Columbia (McNicholl 1980, Western Birds 11:157-159). Ross Lein's 1980 paper on displays of Ovenbird is listed in the bibliography, but its contents do not appear in the text, and its sequel (Lein 1981, Wilson Bulletin 93:21-41) is not listed. Wintering grounds are mentioned for several species, yet the much commented on, very localized Bahama wintering of Kirtland's Warbler receives no mention. Recent evidence suggesting possible nesting of Kirtland's Warbler in Ontario and Quebec is mentioned, but earlier suggestions of Ontario nesting by Harrington in 1939 are not included, even though they were published in *Jack-Pine Warbler*, a journal cited for other studies (*see* Speirs 1985, Ontario Birds 2: 80–84). Hybrid Townsend's x Hermit Warblers are discussed in the account of Hermit Warblers, but not even mentioned under Townsend's Warbler. One could list numerous other examples of life history features not included.

Harrison himself makes no pretensions to comprehensiveness. He set out to fulfill a 30-year ambition to provide a popular account of a favourite group of birds. Thus, each account is a mixture of his personal experiences and those of correspondents and published authors that especially interested him. While he has not provided a series of comprehensive life histories, he has provided a rich variety of interesting facts about Wood Warblers in a highly readable style. His efforts at finding nests for earlier field guides in the Peterson series feature prominently, and he appears to have personal experience with all but Bachman's and Rufous-capped warblers. His lack of experience with Bachman's Warbler does not include lack of knowledge of its habitat, as he tried very hard to track down this endangered species. This is an undercurrent of humour in many of the accounts, especially in frustrating nest searches, or in the frustration at the refusal of Painted Redstarts to face the camera. Alberta naturalists concerned with over-zealous efforts of highway departments in clearing vegetation from the roadside should read Harrison's account of MacGillivray's Warbler — when a highway crew began to attack shrubbery with scythes near a nest that Harrison was about to photograph, he informed them that he was counting rattle snakes, but had only found five so far. Although the species accounts are highly informative, I found the introduction disappointingly vague and scanty. There are very few errors, with the only one of consequence being the transformation of Kennard into Kendeigh in the same paragraph (p. 209).

The breeding range maps appear generally accurate, though generalized. Recent activity in Ontario, especially during atlas efforts, will generate minor changes to the northern limit of several southern species. The black and white photographs range from a very few that are mediocre to many that are excellent. That of a female Brown-headed Cowbird removing an egg from the nest of a Chestnut-sided Warbler may be unique. Apart from J. H. Dick's slightly fuzzy photograph of the almost-never-seen Bachman's Warbler, the colour plates range from good to superb. Most are by Harrison himself. His plate of a pair of Blue-winged Warblers feeding tiny young and that by Betty Darling Cottrille of a pair of Cerulean Warblers at a nest are stunning.

In short, this book does not replace the comprehensive earlier volumes by Bent, Chapman, or Griscom and Sprunt, but does provide a delightful overview of a very appealing group of birds. It deserves space on the library shelf of any naturalist. The photographs alone are worth twice the price.

MARTIN K. MCNICHOLL

Long Point Bird Observatory, Box 160, Port Rowan, Ontario N0E 1M0

Wings in the Sea: The Humpback Whale

By Lois King Winn and Howard E. Winn. 1985. Published for University Press of Rhode Island by University Press of New England, Hanover and London. 151 pp., illus. Cloth U.S. $25; paper U.S. $15.95.

Howard Winn, a professor of oceanography at the University of Rhode Island, has been in the Humpback Whale research business for over 15 years. His wife, Lois, has accompanied him on some expeditions and at times participated in the analysis of data. Their combined talents and experience have produced an appealing, informative book, written primarily for a nontechnical audience. It contains enough previously untold anecdotes and bits of scuttlebutt to make it worth a quick reading by specialists. The first-hand descriptions of at-sea adventures enliven the text and give it a flavor of the rewards and frustrations of field research.

One of the difficulties of producing a book on whales, especially humpbacks, is keeping up to date. Significant observations are being reported at a rapid rate not only in print, but in films and lectures. Since the Winns have been in the process of creating this book for a number of years, I was pleased to find it to be reasonably current, at least through 1983. Of slightly more than 200 titles in the bibliography, more than a third are unpublished. Many of these are graduate theses or abstracts of presentations made at scientific meetings. There is only one reference published in 1984, but in a number of instances the authors mention very recent findings reported to them verbally by colleagues.

I enjoyed the authors' use of the early literature on exploration, whaling, and natural history. Man's acquaintance with the humpback is, after all, ancient and varied in character, by turns fearful, exploitive, and compassionate. The colorful descriptions by those who saw and confronted the whale unaided (or unimpeded?) by cameras, hydrophones, or radiotags provide a rich and often entertaining context for new insights.

Having pored over many old whaling accounts and struggled to interpret them myself, I was disappointed by the authors' failure to note their sources within the text. They could have done so unobtrusively, simply by numbering the references in the bibliography and citing the appropriate number after a given quotation. Apparently many of the long quotations are quotations of quotations found in secondary sources, but even the secondary sources cannot be identified in many instances.

There are strange inconsistencies in the way some of the old quotations are used. For example, following a delightful description by an eighteenth-century sailor of his first observation of a humpback breaching off Bermuda, there is a quotation from William Scoresby (senior, I assume). Scoresby was a Greenland man, a hunter of the Bowhead Whale. His account of breaching almost certainly pertains to bowheads, not humpbacks. Yet the Winns proceed with their own essay on humpback breaching "styles" without bothering to mention that Scoresby probably was writing about a different species in circumstances altogether different than those in which most of their own observations were made.

The authors sometimes seem overly credulous in their regard for the words of early commentators. Though they express "some doubt about the authenticity" of a report of an 88-foot (26.8 m) female humpback caught off Bermuda (year not stated), the Winns consider 74 feet (22.5 m) a "realistic estimate" for the length of humpbacks in the Persian Gulf. Yet of the many thousands of measured humpbacks taken in the North Atlantic, North Pacific, and southern ocean during the twentieth century, the largest was about 18 m long. Thus, 18 m must be close to the asymptotic length for this species, worldwide. Nearchus, the source of the 74-foot estimate, was a Greek sailor who made a voyage along the coast of Pakistan during the fourth century B.C. He reported seeing many large whales, but as the Winns themselves admit, "we cannot be sure Nearchus saw humpbacks." What, then, was the basis of his length estimate for humpbacks? I could have investigated this question myself but, alas, I had no way of figuring out where the Winns got their information about Nearchus and his observations.

The authors claim there is little scientific evidence that swordfish attack whales, "other than two reported instances of swords from swordfish being found embedded in the carcasses of whales." In fact, I could readily find eight well-documented published records of such finds, as well as at least two credible eyewitness accounts of billfish attacks on whales (most recently that by P. F. Major 1979, pp. 95–96 *in* Scientific Reports of the Whales Research Institute, Tokyo, No. 31).

I liked the black and white photographs and found most of them complementary to the text. Many have not been published previously. The stippled drawings that divide chapters, however, are largely superfluous. What they show is invariably better shown in the photographs distributed throughout the text. A notable exception is the divider for the last chapter, "The Future". It shows a child sitting on a rocky shore, watching a humpback dive. Such scenes should become increasingly common as *Megaptera novaeangliae*, the "large-winged New Englander", continues to recover from overexploitation.

RANDALL R. REEVES
Box 99, Como, Quebec J0P 1A0

BOTANY

Pondweeds and Bur-reeds, and Their Relatives, of British Columbia

By T. Christopher Brayshaw. 1985. Occasional Papers Series No. 26. British Columbia Provincial Museum, Victoria. 166 pp., illus. $15.00.

Although Canada has produced many floristic manuals and checklists, we have for a long time been at a relative disadvantage with respect to aquatic vascular plants. While other regions are covered by comprehensive, well illustrated, and easy-to-use guides, Canada has had to resort to minimal information in more technical works covering broad geographical areas.

Various aquatic plants are significant as food and cover for waterfowl and other wildlife, as serious weeds costing millions of dollars to control, as indicators of water quality, as a mechanism for purifying water, and in many other ways. The lack of a convenient means of identification and comprehensive information on local occurrence has naturally been frustrating. This problem has now been largely eliminated in the province of British Columbia. Although the publication does not include all of the aquatic vascular plants in the province, it does cover some of the major groups and they are covered very completely. Furthermore a key to all genera of British Columbia aquatic vascular plants is included.

In the introduction Mr. Brayshaw describes the collections which are the basis for the work and the classification that is used. A checklist of species and varieties is included, and excluded species are explained. The different types of wetlands and successional trends are described under a section entitled "The Aquatic Environment". In addition, interactions among aquatic plants are discussed and features of the aquatic environment are considered with respect to adaptation. Aquatic plants tend to have thin and dissected leaves to compensate for the low solubililty and diffusion rate of gases in water. The introduction is packed with this kind of information, and it provides a good basic understanding of aquatic plant biology. The introductory section concludes with an account of evolution and classification, and the key to all genera of aquatic vascular plants in British Columbia, as well as a key to the genera included in the publication. Throughout this introductory section, and elsewhere, Mr. Brayshaw has achieved his goal of making the work widely usable through the avoidance of excessive technical terminology, and through the use of a conversational style.

The keys throughout the book are designed to facilitate identification and are based on readily observed features. They are also generally accurate and based on the most recent taxonomic work. The key to all genera includes a number of plants that are not aquatic, but rather wetland plants, such as *Ledum groenlandicum* and *Cornus stolonifera*. Thus the aquatic concept has not been used to the best advantage, but this is a minor shortcoming.

The main part of the book includes descriptions of families, genera and species, and the keys to species. The descriptions are short but adequate. Brief notes on habitat and distribution are provided for each species as well as a cross reference to a distribution map at the back of the book.

Each species is illustrated by the author and the illustrations are of good quality. The work concludes with a partly illustrated glossary, the distribution maps, bibliography, and an index.

The book has a soft cover and is approximately 20 x 27 cm, making it a little large for convenient field use. The print is of good quality and there is effective use of page space without compromising an agreeable layout. Unfortunately, the paper is rather thin, and the "perfect" binding will result in pages falling out, a problem that could have been overcome by adding a couple of staples.

With occasional paper no. 26, the British Columbia Provincial Museum has produced an outstanding publication and Mr. Brayshaw has made a substantial contribution to aquatic plant biology. The book is comprehensive and the information is readily accessible. It will serve professional biologists, consultants, naturalists, and lakefront cottage owners. Many of the species illustrated and keyed occur outside British Columbia, so that it will be of some use in the immediately surrounding areas as well. It is good value for $15.00.

PAUL M. CATLING

Biosystematics Research Centre, Agriculture Canada, Central Experimental Farm, Ottawa, Ontario K1A 0C6

The Flora of Manitoulin Island and the Adjacent Islands of Lake Huron, Georgian Bay and the North Channel

By J. K. Morton and J. M. Venn. 1984. Second Revised Edition. Department of Biology, University of Waterloo, Waterloo. 181 pp. + 106 pp., maps. $18.00.

Anyone venturing to produce a comprehensive regional flora is taking on a difficult and often poorly appreciated task. While the flora may be no less demanding to produce than a regional manual, it rarely receives the same level of recognition. Nonetheless, the authors of *The Flora of Manitoulin Island* have taken on the challenge of preparing a detailed annotated list and have even expanded their efforts to include elements usually confined to regional manuals. I'm delighted to report that the result of their labours is a wonderful addition to the libraries of field naturalists across Ontario (and beyond).

Working from John Morton's 1977 preliminary checklist, the authors conducted extensive field studies throughout Manitoulin Island and the 53 outlying islands adjacent to it. These efforts resulted in over 60 000 observations and collections being documented.

An informative and interesting introduction initiates the discussion of these findings. The geological history of Manitoulin, its glacial and post-glacial impacts and the important influence of contempory climate and temperature are described. These lucid and useful descriptions are followed by a discussion of previous botanical explorations. An excellent classification of the vegetation of Manitoulin follows. Typical species for each floristic element (e.g. Boreal Forest, Eastern Deciduous Forest, etc.) are listed with each discussion. The authors go on to discuss the computerized data collation that they employed and to advise others who might be considering such an approach to assess their options carefully before committing themselves to this expensive and demanding technique. This provides a refreshingly candid discussion of the pros and cons of such a venture.

The introduction is concluded with an annotated listing of species that are reported elsewhere as being in Manitoulin but which the authors exclude in their treatment. That excellent feature should be a standard part in all floras but is unfortunately all too rare at present.

The species list includes over 1220 taxa, placed alphabetically in a family order that quite closely follows that of Gray's Manual (Eighth Edition). Scientific and common names are provided for each species, as is synonomy for newer combinations. These treatments are excellent. The habitat for each species is well described in terms of the vegetation types discussed in the introduction. Flowering and fruiting dates are offered (where applicable) and are a useful addition. Excellent keys to the Manitoulin Island species of a number of difficult groups are provided as part of a discussion of the taxonomy of such groups. Difficult genera like *Carex, Juncus, Poa, Potamogeton* and *Viola* are treated in this manner and it helps one understand the Manitoulin Island situation much more easily. Well-defined and remarkably comprehensive range maps are presented for each species in an appendix. These maps are computer-generated from the immense collection of records amassed during this study. Another appendix lists the plant species known from each of the 53 adjacent smaller islands — an impressive document in itself. A very attractive section of colour photographs of various Manitoulin Island plants provides a 17-page gallery that may not offer very much in terms of information but which certainly brightens up the book.

There are two indices. One includes scientific names of genera and families and the other lists common names. These separate indices are unnecessarily cumbersome for the reader and would have been more useful if combined. The differently coloured paper used for the indices makes them stand out easily. As the indices are placed before rather large appendices, this feature is particularly useful in providing quick access to them.

There is little to question in the production of this book. Typographic errors appear to be few. The layout and type-face used make for good readability of the text. While the volume is available only in paperback, the book seems well-bound and is quite durable. A lot of care has obviously gone into making this an attractive book as well as an informative one. This leads me to wonder why the authors have retained the rather uninspiring cover utilized in the first edition — especially when so many beautiful visuals were available elsewhere in the book. This, however, is a minor quibble.

The Flora of Manitoulin Island is an excellent book that should be acquired by anyone interested in the flora of southern Ontario or by those contemplating producing an annotated regional list of their own. The quality of research, production and description provided by Morton and Venn should serve as an excellent model for others. We could certainly use many more like this one!

DANIEL BRUNTON

2704 Marie Street, Ottawa, Ontario K2B 7E4

The Vascular Plants of Louisiana: An Annotated Checklist and Bibliography of the Vascular Plants Reported to Grow without Cultivation in Louisiana

By D. T. MacRoberts. 1984. Bulletin of the Museum of Life Sciences 6: 1–165. Louisiana State University, Shreveport. U.S. $10.00.

To produce a checklist of the flora of Louisiana by the standard method of checking herbarium specimens would have been, according to the author, an extremely time consuming task for a flora which he lists as including 885 genera, 2952 accepted species, 390 questionable species and 253 cultivars. Dr. MacRoberts has chosen to produce his checklist by using the bibliographic method. Thus, as he says, his work depends on others, but it is critical.

The checklist is divided into the large groups of Pteridophyta and Spermatophyta, the latter being further divided into Gymnospermae and Angiospermae with the subclasses of Monocotyledonae and Dicotyledonae. Families, genera and species are in alphabetical sequence within each of the large groups. That is where the similarity to a basic checklist ends.

For each species in the list there is a bibliographic reference. The reference selected is chosen on the basis of an order of merit from most favourable to least favourable, as explained in his introductory "Rationale". At the end of each family there are usually extensive notes which will be invaluable to any botanist studying the flora of the state. These are referred to in the lists by an asterisk after a particular species. Also included here are lists of questionable species and cultivars.

The bibliography is not just a bare list of authors and titles with their accompanying journal or book information. Most entries are accompanied by cryptic comments such as "Citations; herbaria identified" or "Keys, descriptions; dot distribution maps." Such information would be useful in any bibliography.

Another innovation is found in the index where synonyms are immediately followed by an equals sign and the accepted name, e.g. *Sabina* = *Juniperus*.

Introductory materials include an "Apologia pro opus suus", "Rationale" and sections on discussions of nomenclature, coverage, format and treatment, early collectors, the modern era, the condition today, herbarium resources in Louisiana, threatened and endangered species, effectiveness of the method of developing the list, acknowledgments, and a summary by family of the composition of the Louisiana flora.

This rather revolutionary method of producing a checklist of a region is certainly most interesting and indeed much of the research required to write a flora of Louisiana has been done, but the fact still remains that the writer of that flora will have to examine herbarium specimens and make taxonomic decisions if the resulting treatment is to be of real and lasting value.

WILLIAM J. CODY

Biosystematics Research Centre, Agriculture Canada, Ottawa, Ontario K1A 0C6

The Vascular Plant Flora of Peel County, Ontario

By Jocelyn M. Webber. 1984. Botany Press, Toronto. 94 pp. $10.00.

The purpose of this book is, according to the author, to "make some contribution to our understanding of the flora and vegetation of Ontario." And it does. It provides information on 1334 taxa of trees, shrubs, ferns, and herbs which occur, or are known to have occurred, in Peel County without maintenance by humans.

Unfortunately, the title is somewhat misleading. Some readers may purchase this book purely on the strength of the word "Flora" in the title and expect to find illustrations, descriptions, and keys to the identification of all vascular plants in Peel County. They will be disappointed on all three counts. Instead, they will find a list of scientific names of plants arranged by family, genus, species, and subspecific rank, where included. Accompanying each scientific name is a common name in the English language, an indication of the township(s) in Peel County (as constituted prior to 1974) in which the plant occurs or occurred, a numerical abundance code, and for most, an anecdotal statement of occurrence such as, "Edges of streams and rivers," "Restricted to crevices in limestone cliffs of the Niagara Escarpment," "Known only from a bog between Heart L. and Teapot L.," or "Only recorded 1906 from Snelgrove." In the Introduction the author justified her choice of title by stating that "A flora is an inventory of plant species of a defined area. A checklist is a list of plants." However, my dictionary defined "inventory" as "1. Detailed list (of goods, furniture, etc.)" Confusion compounded when I found that it also defined "flora" as "(List of) plants of particular region or epoch (cf.

fauna)"! Nevertheless, it is my impression that the term 'flora', when referring to a book, is now generally accepted as implying keys or descriptions or both. Obviously recognizing the problem in terminology, the author proceded to distinguish as "major floristic works" those which "contain taxonomic keys to certain plants groups or the entire flora of an area," and then specified several such major works which may be consulted for this area. They include *Grasses of Ontario* by Dore and McNeill, 1980 (reviewed in the Canadian Field-Naturalist 95(2): 223–224), and *Gray's Manual of Botany* by Fernald (1950, Eighth Edition). She also mentioned the illustrated pocketbook, *Trees, Shrubs and Flowers to Know in Ontario* by McKay and Catling, 1979, as a useful aid for the beginner.

The 25 pages of text preceding the 58 pages of checklist provide brief discussions of the physical environment of the area, its phytogeography, the classification of vegetation types, the history of botanical studies in Peel County, and the procedures and criteria for the checklist. Township and county configurations prior to implementation of regional government in 1974 were selected for this checklist because this was the terminology used on many of the historical plant records on which it is based. Maps of the former county and the new Regional Municipality of Peel permit correlation of the one with the other.

Of the 1334 distinct plant taxa recorded for Peel, 36.4% are naturalized introductions, 5% are provincially rare plants which still occur in this county and about 10% are believed to be extinct (no records since 1962). This last statistic, as innocuous as it may seem, should be taken as a clear warning to the rest of southern Ontario (and other highly urbanized areas) that the individual components of our native flora are not immune to extirpation and that we, collectively, have an obligation to preserve these irreplaceable parts of our natural environment.

The author is to be congratulated on the thoroughness of this list and the care in its compilation. The few errors which have been noted are mostly typographical, although a few are inconsistencies such as the common name for the annual herbaceous weed, *Conyza canadensis*, being given as 'horse-weed' (taken from *Manual of Vascular Plants* by Gleason and Cronquist, 1963) rather than 'Canada fleabane' (the name in *Common and Botanical Names of Weeds in Canada* by Alex et al. 1980, (reviewed in the Canadian Field-Naturalist 94(4): 491–493) which was specified in the Introduction as the source of common names). It will be a useful supplement to other botanical works dealing with Peel County and the stated purpose of this book will be achieved.

J. F. ALEX

Department of Environmental Biology, University of Guelph, Guelph, Ontario N1G 2W1

Pines, Drawings and Descriptions of the Genus *Pinus*

By Aljos Farjon. 1984. E. J. Brill/Dr. W. Backhuys. Leiden. 220 pp., illus. D.Gld. 96.

This is not a taxonomic treatment of the genus *Pinus*, but is for the greater part a collection of drawings together with descriptive information.

For each of eighty-one species of pine there is a page illustration which usually includes a habit drawing of the tree, the cone, the needles, and sometimes twigs and seeds, all drawn by the author. For these, the author has travelled to many parts of the world to draw the trees in their native habitat. Herbarium material has been used as a supplement when fresh material was not available. The habit drawings are good, but the cones are particularly well done. On the facing page is an easily read description, together with notes on the ecology and distribution, a small world-wide map, the scientific name, occasional synonomy, and English common names, if any. Descriptive information is also given for an additional six rare or very localized species that presumably could not be seen and examined in the field. The species are in alphabetical order of scientific name. There are no keys, but for those wishing to identify specimens, the drawings, descriptions and geographic limitations should suffice.

The author is a dendrologist. His treatment is a mixture of very simple information, eg. "Pines are woody plants," to cladograms depicting the taxonomic and geographic relationships of the species. The introduction includes information regarding the placement of the Gymnospermae in the Spermatophyta and the further division of the Gymnospermae into several families, and so on. Mention is made of successive monographers treating the genus. Several pages are devoted to illustrations and descriptive information on inflorescences, morphology and development of pine cones, germination and growth of a pine, the root system, the bark of a few species, a transverse section of a tree trunk, a shoot with needles, and cross-sections of

needles of both diploxyl and haploxyl types of pines. The detail in these drawings appears to be quite good, but the information is of a textbook nature.

Two pages on the phylogeny and biogeography of the genus *Pinus* were contributed by Dr. J. van der Burgh.

A glossary, an index of botanical masses, a short bibliography, and a page of acknowledgments complete the book which has a hard cover and measures about 23 x 32 cm.

WILLIAM J. CODY

Biosystematics Research Centre, Agriculture Canada, Ottawa, Ontario K1A 0C6

Catalogue of Herbarium of William W. Judd, University of Western Ontario

By William W. Judd. 1984. Phelps Publishing Co., London, Ontario. ii + 66 pp. $5.00.

The usefulness of this catalogue of a small (818 sheets) private herbarium, recently donated to UWO, is, unfortunately, greatly reduced by the sequence of entries, which is according to accession number. These bear no relation to any taxonomic sequence — *Lindera benzoin*, for example, appears at nos. 3 and 811 — nor even to locality and chronology — six specimens collected at one locality during a two-day visit are scattered between no. 36 and no. 233. The species represented are mostly common, from southern Ontario and from other localities extending from Labrador to the Yukon and south to Maryland. There are some noteworthy records, but the format precludes conveniently looking for species of interest. The locality data are regrettably lacking in detail, usually being no more precise than "Hamilton, Ont." or "Prince Albert National Park, Sask."

Probably of greater interest to historians of botany will be the appendices providing biographical data on Dr. Judd, his family, and donors of specimens, and indicating the circumstances under which many of the specimens were collected, for example, in connection with one of Dr. Judd's entomological studies. There is an extensive list of publications documented by or otherwise associated with the specimens.

JAMES S. PRINGLE

Royal Botanical Gardens, Box 399, Hamilton, Ontario L8N 3H8

AMA Handbook of Poisonous and Injurious Plants

By K. F. Lampe and M.A. McCann. 1985. American Medical Association (Distributed by Chicago Review Press, Chicago). 431 pp., illus. U.S. $18.95.

This handbook covers the major poisonous plants which are native, introduced, and horticulturally present in the United States, Canada, and the Caribbean. It may be useful for field botanists or natural historians to acquire this work because most botanical texts and floras do not include plants of horticulture except "garden escapes" or "waifs", some of which may be extremely toxic. With the exception of a few avid plants persons, many professional and amateur botanists have not acquired a knowledge of both native and cultivated toxic taxa. Since field botanists may sometimes be called upon to identify toxic plants for our medical colleagues at regional poison control centres, this publication may fill a useful niche on their bookshelves.

The text contains, in addition to the 437 colored photographs of plants, 163 pages of the taxa's nomenclature and common names, under which a resumé is given of the description, distribution, toxins, toxic symptoms, patient management, and a relatively current phytochemical bibliography.

Initial or introductory tables (1 and 2) list frequently encountered poisonous species. Others tabulate signs and symptoms of common/serious plant intoxicants or lists plants producing systemic poisoning according to Family and Genera. The index contains over 2300 scientific and common names of plants contained in the publication. Tables are also given which present six major groups of plants based on their toxic properties i.e. 1) contact dermatitis, 2) stinging hairs or needles, 3) irritant raphides, 4) irritant sap or latex, 5) phytophotodermatitis, 6) allergic contact dermatitis. A mycologist colleague, Dr. Scott Redhead, examined the small section on mushroom poisoning and found it to be accurately presented.

It is interesting to see plants photographed and

shown at various stages of their life history, e.g. Lily-of-the-Valley (*Convallaria majalis*) is shown in flower and in fruit; likewise Poison Hemlock (*Conium maulatum*) is presented thrice — a habit photo, a close up of the flowers and one showing the stem and ochrea. Dumbcane (*Dieffenbachia maculata*) is photographed showing leaf variants of three cultivars. Jimson Weed (*Datura stramonium*) merits four photographs showing flowers, fruits and its mauve flowered variety var. *tatula*.

Minor criticisms include off-tone colour reproduction of some of the vascular plants and mushrooms. Some botanists may be irritated because the volume is not systematically arranged by family. Placing the plants in generic order throughout the main body of the text probably is a compromise to non-botanists who no doubt will be the major users of this handbook.

The handbook is 11.5 x 20 cm; it can be easily carried to the field and has an attractive jacket and dustcover. It physically resembles the handbooks produced by the Audubon Society and based on the valuable data it contains is a bargain at $18.95 (U.S.).

C. W. CROMPTON

Biosystematics Research Centre, Agriculture Canada, Ottawa, Ontario K1A 0C6

ENVIRONMENT

Islands at the Edge: Preserving the Queen Charlotte Islands Wilderness

By the Island Protection Society. 1984. Douglas and McIntyre, Vancouver. 160 pp., illus.

This book is about South Moresby, located at the south end of the Queen Charlotte archipelago adjacent to the coast of British Columbia. It is a book about a part of Canada that even the local residents think of as a special place: a refugium from the last ice age which supports an ancient and unique ecosystem, but which is now a candidate for economic development because of a proposed logging program. It provides a glimpse of the history, the culture, the archaeology, and the biology of South Moresby.

This beautifully illustrated, and rather poetic volume, is introduced by J. Cousteau, who sets the mood by writing, "our wisdom tells that we still have much to learn, even from the most modest cells. Our conscience forbids us to be destructive since we have finally understood that a superior moral order takes precedence over economic considerations."

South Moresby is part of a chain of 138 islands containing approximately 160 km of coastline characterized by a diverse array of intertidal sea life. It is the home of the world's largest Black Bear, a unique Pine Marten, and 25% of all the nesting seabirds in the Canadian Pacific; 7 land mammals found on South Moresby show evolutionary characteristics distinct from related mainland species. It is referred to as the Canadian Galapagos.

In the first section, B. Reid describes the settlement of North America in the context of the Christian doctrine, which is exemplified by the statement, "go forth and multiply and rule the earth." Reid provides a short, passionate account of mankind's destruction of the natural world. South Moresby is presented as "one of the few isolated conclaves of the natural world yet to be consumed by modern man."

The second section is composed of four essays on the natural history of the area. The end of each chapter contains a short section on the impact of man's activities (eg. logging and oil spills) on the environment. Dr. J. B. Foster reviews the special evolutionary features of the Queen Charlotte Islands, and describes the unique assemblage of mammals, plants, birds, fish, and insects found here. He describes the formation of the islands (eg. plate tectonics), and reviews the evidence in support of the ice-free refugia theory.

J. Pojar and J. Broadhead describe South Moresby's plant life as "a complex and ancient tapestry" where "a visitor can step ashore in a quiet intertidal estuary, enter the west coast rain forest, traverse the whole range of natural communities up into the alpine, to a vista of the rugged west coast and the open Pacific Ocean, all in a matter of hours." The authors describe the vegetation zone (eg. the coastal strip forest and the alpine) in some detail.

The marine environment is addressed by D. Denning who traces some of the complex food webs of South Moresby and describes them in the context of some of the endemic species found here. The estuaries are important environments for waterfowl, shorebirds, and salmon migrating to and from the associated streams. There are more than 50 streams providing habitat for Pink, Chum, Coho, and one run of Sockeye salmon. Denning writes that he knows "of no mixed-bottom beach along the entire Pacific coast that can compare in the sheer wealth to one site in the South Moresby wilderness area."

W. Campbell outlines the nutrient cycles of the northeastern Pacific and the "phenomenal seabird and raptor populations which have developed as an integral part of them."

The last section contains two chapters devoted to the development issue of the South Moresby controversy. J. Broadhead documents the events which have transformed this issue into one which is now receiving international recognition. T. Hemley addresses the hazards of popularizing a wilderness area for the purpose of saving it, since this could conceivably result in increased stress on a fragile ecosystem.

The book is illustrated with photographs of a collection of paintings of the area, colour photographs, historical photographs (black and white), and two maps. I recommend this book to all who are interested in South Moresby and the issues surrounding it.

PAUL A. GRAY

Biology Department, Faculty of Science, York University, Downsview, Ontario M3J 1P3

Effects of Pollutants at the Ecosystem Level — SCOPE 22

Edited by Patrick J. Sheehan, Donald R. Miller, Gordon C. Butler, and Phillipe Bourdeau. 1984. John Wiley and Sons, New York. xv + 443 pp., illus.

The Scientific Committee on Problems of the Environment (SCOPE) was established by the International Council of Scientific Unions, which consists of 98 international agencies, to assemble and review information on the effects of human activities on the environment, and to establish itself as an intelligence service on current environmental research.

This book reviews current knowledge of the effects of pollution on whole ecosystems. The first half of the book develops theory and concept, while the second half presents case studies illustrative of these theories and concepts.

The first three chapters after the introduction set the stage for later discussions of ecosystem effects. Chapter 2 gives an overview of pathways followed by toxic chemicals in the environment, and of interactions between chemical and environment. The third chapter examines problems inherent in distinguishing ecosystem responses in the face of wide natural fluctuations in ecosystem parameters. Chapter 4 reviews the effects of pollution on individuals and populations, and effects on population success and population interactions.

Chapters 5 and 6 focus on the central theme of the book — pollution effects on communities and ecosystems. The fifth chapter provides an in-depth review of response in terms of organism abundance, biomass, species composition, species diversity, similarity indices, community stability, community succession, and recovery. A great variety of quantitative structural indices used to analyze community response is presented in comparative and summary fashion. Many are shown to provide conflicting interpretations of a given polluted ecosystem — quite often the simpler indices such as species richness (number of species) are most reliable. Chapter 6 explores responses at the functional community level, examining the dynamic processes of material and energy flow that keep ecosystems running. Studies on acidic precipitation, heavy metals, pesticides, and oil pollution are reviewed to illustrate responses in decomposition, elemental cycling, productivity, and respiration.

Case studies in the second half of this book cover a variety of pollution problems in several aquatic and terrestrial environments. The first provides an historical account of water pollution in the Thames River estuary and an excellent quantitative description of ecosystem recovery following clean-up, with emphasis on fish community structure. The Clearwater Lake study examines structural and functional responses in an Ontario lake affected by acidification and metal pollution and subsequently neutralized by lime. In the third case study, structural responses of benthic communities are compared along heavy metal gradients in three polluted streams. The Churchill-Nelson River Diversion study applies ecosystem analysis to assess aquatic impacts caused by physical rather than chemical perturbations in a major hydroelectric development in Manitoba. The final aquatic ecosystem study explores the impact of large oil spills on the population parameters of commercially valuable marine fish and shellfish along the Brittany coast.

The three concluding case studies focus on polluted terrestrial ecosystems. The first examines ecosystem parameters in an English woodland along a gradient of airborne heavy metals. The second terrestrial study reviews the responses of spruce budworm populations and non-target organisms to aerial spraying in New

Brunswick, and uses past experiences in environmental monitoring and forest management to conceptualize a more rational framework for ecological monitoring and forest pest management. In the final terrestrial case study, an account of efforts to re-establish an ecosystem on sterile mine tailings is provided, highlighting the problems encountered in establishing and maintaining the necessary nutrient cycles and physical conditions for community development.

A final chapter wraps up by drawing a concise set of lessons and conclusions from the book, and by stressing the need to adopt study approaches that are sensitive to the diagnosis of effects at the whole ecosystem level.

My opinion of the book is generally favourable, although the book does suffer from a few fairly minor problems. While there are 8 chapters, Chapter 7 accounts for half of the book. Organization might be improved by assigning each case study individual chapter status. Chapters in the first half of the book are coordinated, and lead well into the next. Some of the case studies deviate somewhat from the central theme—ecosystem effects. For example, the discussion of responses to oil spills is confined primarily to effects at individual and population levels. The book also contains very occasional typographical errors and, in my copy, a minor reproduction problem on page 19.

The book follows a broad subject in a logical sequence and well-organized fashion. The concepts developed in the initial chapters, along with descriptions of their practical application in pollution studies, will be valuable in the design of effective programs to monitor effects at community and ecosystem levels. This is an area where such direction is sorely lacking. I recommend this book to environmental managers, ecologists, and advisors to government and industry.

PAUL MCKEE

Beak Consultants Limited, 6870 Goreway Drive, Mississauga, Ontario L4V 1P1

Historical Account of Byron Bog (Sifton Botanical Bog), London, Ontario

By William W. Judd. 1985. Phelps Publishing Co., London, Ontario. iii + 61 pp. $5.00.

Probably few field biologists in Ontario have not heard of the Byron or Sifton Bog, a favourite haunt of generations of London naturalists and now an important educational resource. As this review is being written, the bog is much in the news, because of threats to its ecology from actual and proposed developments on adjacent properties. The fame of the bog is due in significant part to well over 50 papers by Dr. William W. Judd. Biologists may be most interested in his two *Diaries of observations* (Phelps Publishing Company, 1982, 1984), which contain lists of the plants and animals.

The publication reviewed here deals with the human history of the bog and its environs. There are brief considerations of the oldest archaeological records of human occupation, exploration of southern Ontario by the French and British, and early surveys and political subdivisions. The largest part of this work comprises a detailed account of the successive ownership of all tracts of land that include or approach any portion of the bog, a surprisingly large list in view of the approximately 28 ha extent of the bog. This portion concludes, appropriately, with an account of the acquisition of the bog as a nature preserve by the Upper Thames River Conservation Authority in 1958-1966. The final chapters include an account of the development of educational facilities, a brief history of research at the bog, and a discussion of the names by which the bog has been known. All parts are accompanied by Dr. Judd's characteristically thorough documentation.

From a multitude of sources, ranging from county records to interviews with long-time residents of nearby homes, Dr. Judd has provided detailed records of the uses made of the bog and adjacent uplands by the long succession of landowners. In the bog itself, these extend from early and fortunately short-lived attempts at drainage and peat extraction to the more recent cutting of Christmas trees. The surrounding uplands have been the sites of homes, pastures, orchards, and ornamental plantings. Many of these developments have had some lasting effects, major or minor, on the topography and biota of the bog. Therefore, all those who study or interpret the ecology of this renowned nature reserve in years to come will be fortunate indeed to have this remarkably thorough record of human influences, along with Dr. Judd's many other studies of the site.

JAMES S. PRINGLE

Royal Botanical Gardens, Box 399, Hamilton, Ontario L8N 3H8

The Northern Naturalist

By E. Otto Hohn. 1983. Lone Pine Media Productions, Edmonton. 173 pp., illus. $12.50

Active field naturalists who frequently publish their more unusual findings in *The Canadian Field-Naturalist* and other journals accumulate a vast store of knowledge of more "mundane" facts that rarely see the printed page unless they concern a species that has received special attention from the naturalist in question. A few do get around to offering a collection of these more routine observations in book form, and with the recent resurgence of interest in general natural history, the frequency of such titles on the market is increasing. Otto Hohn's *The Northern Naturalist* is of this genre, and is among the very few dealing primarily with a transitional habitat between the coniferous forest and the prairie grasslands, known as the aspen parkland.

The book is centred on the Cooking Lake Moraine slightly east of Edmonton, Alberta, and is not especially northern by Canadian standards. However, the author does frequently digress to Arctic lands, as well as childhood and early career experiences in Europe, and sabbatical visits to the Argentine pampas and elsewhere. The text is divided into three parts, the first of which is a capsule view of the aspen parklands in general, with glances at changes for better or worse that have resulted from the occupancy by European settlers. Seven sketches on particular animals (four bird, three mammal) follow, after which four longish essays on the seasons conclude the main text. Hohn knows his subject well from many years of field work and is at his best in readability when he rambles through personal experiences, such as swimming among phalaropes. The text often flows along enthusiastically, though it frequently strays rather far off topic — I am not really sure how four pages on Banks Island nesting grounds of geese fit into a 16-page chapter on autumn in the parklands. Although Hohn's professional interest in avian endocrinology occasionally peeks through, the writing is primarily that of a naturalist, and much of it offers an enjoyable read. On the other hand, the text from time to time bogs down in choppy vignettes of unrelated observations, some of which appear to be thrown in as random thoughts. Nevertheless, even these observations help to convey an overall picture of a habitat which receives little attention outside the prairie provinces. Hohn also knows the literature well, and although he does not cite literature as one would in a journal article, he does refer to published works from time to time, most of which are included in a two page, rather eclectic list of sources. A book by Stanley Young on Bobcats is mentioned but not listed, and several books listed are not mentioned in the text.

Although Hohn's writing is uneven, I detected no genuine errors of fact. His statement (p. 102) that Brown-headed Cowbirds are our only brood parasite is not strictly true, as redheads are frequent brood parasites, Black-billed Cuckoos occasionally parasitize other birds, and several other bird species are known to indulge in this behaviour rarely. If he had said our only species that is exclusively a brood parasite, his statement would have been correct. "Extirpated" would have more accurately described the demise of bitterns (p. 104) and Peregrines (p. 140) in Britain than "extinct." There are an unfortunate number of typographical errors, most involving the spelling of species names, especially hyphenations and spacings. A new species, the "billed" kingfisher is erected in the introduction (p. 16) in a list of full names for species mentioned by shorter names in the text, and the same list mentions yellowthroat but neglects to spell out the full name. The error in the kingfisher name is repeated in the index (p. 172), where the Red-backed Vole is renamed "red-breasted," though the text uses the correct name. The index is a welcome feature too often lacking in books of this genre — how else would one find details of the ground-nesting Long-eared Owl discussed in the sketch on Cooper's Hawk? Unfortunately, the index is incomplete and very inconsistent. A random check showed Dick Dekker, Sir John Franklin and flying squirrels as subjects on more pages than indicated in the index. Franklin's Gull is indexed under gull, Franklin's Ground Squirrel under Franklin. Some species (e.g. Northern Shoveler and White-winged Scoter) are listed under family names that do not appear in their species names — in these cases, ducks. Others (e.g. Moose and redpolls) are listed under their own names, not deer or finches. Snow Buntings and Snowshoe Hares are listed under snow!

Despite its eccentricities this book does provide a pleasant anecdotal introduction to an interesting habitat. To those of us who spent our formative years under the cover of *Populus tremuloides*, Hohn has managed to bring back many delightful memories. This book does not much resemble a guide as indicated by the author, but does provide a nice overview.

MARTIN K. MCNICHOLL

Long Point Bird Observatory, P.O. Box 160, Port Rowan, Ontario N0E 1M0

NEW TITLES

Zoology

The amazing armadillo: geography of a folk critter. 1984. By Larry L. Smith and Robin W. Doughty. University of Texas Press, Austin. xi + 134 pp., illus. Cloth U.S. $13.95; paper U.S. $16.95.

Arctic animals. 1985. By Jonquil Graves and Ed Hall. Department of Information, Government of the Northwest Territories, Yellowknife. 96 pp., illus. $7.50.

Bats: a natural history. 1984. By John E. Hill and James O. Smith. British Museum of Natural History, London. 248 pp. £15.

Behavioural ecology: an evolutionary approach. 1984. Edited by J.R. Krebs and N.B. Davies. Second edition. Blackwell Scientific (distributed by Sinauer, Sunderland, Massachusetts). xii + 493 pp., illus. Cloth U.S. $45; paper U.S. $27.50.

Biology of Australasian frogs and reptiles. 1985. Edited by Gordon Grigg and Harry Ehmann. Surrey Beatty and Sons, Chipping Norton, Australia. c600 pp., illus. A. $56 plus postage.

*__Biology of the Chrysopidae.__ 1984. Edited by M. Canard, Y. Semeria, and T.R. New. Junk, The Hague. 294 pp., illus. Dfl. 150.

Birding with a purpose: of raptors, gabboons, and other creatures. 1984. By Frances Hamerstrom. Iowa State University Press, Ames. viii + 130 pp., illus. U.S. $13.95.

*__Birds of the Orkney.__ 1985. By C. Booth, M. Cuthbert, and P. Reynolds. Orkney Press, Stromness, Orkney, United Kingdom. xxv + 275 pp., illus. £12.

The birds of Yorkshire. 1985. By John R. Mather. Croon Helm, Beckenham, England. 450 pp. £14.95.

The control of fish migration. 1985. By R.J.F. Smith. Springer-Verlag, New York. xvi + 243 pp., illus. U.S. $49.50.

The ecology of mixed-species feeding groups. 1985. By C.J. Barnard. Croon Helm, Beckenham, England. 288 pp. £17.95.

The encyclopedia of mammals. 1984. Edited by David MacDonald. Facts on File, New York. 929 pp., illus. U.S. $45.

Fish migration. 1984. By Brian A. McKeown. Croon Helm and Timber Press (distributed by International Specialized Book Services, Portland, Oregon). x + 224 pp., illus. U.S. $29.

Form and function in birds, volume 3. 1985. Edited by A.S. King and J. McLelland. Academic Press, New York. c476 pp.

Freshwater fishes of California. 1984. By Samues M. McGinnis. University of California Press, Berkeley. 350 pp.

A functional biology of sticklebacks. 1985. By R.J. Wootton. University of California Press, Berkeley. xiv + 265 pp., illus. U.S. $29.95.

*__The giant pandas of Wolong.__ 1985. By G.B. Schaller. University of Chicago Press, Chicago. U.S. $25.

The grizzly bear. 1984. By Thomas McNamee. Knopf, New York. vi + 308 pp., illus. U.S. $18.95.

The grizzly in the Southwest: documentary of an extinction. 1985. By David E. Brown. University of Oklahoma Press, Norman. xx + 274 pp., illus. U.S. $19.95.

Handbook of Canadian mammals, 2: bats. 1985. By C.G. van Zyll de Jong. National Museum of Natural Sciences, Ottawa. 212 pp., illus. $19.95.

†__Honeybee ecology: a study of adaptation in social life.__ 1985. By Thomas D. Seeley. Princeton University Press, Princeton. 193 pp., illus. Cloth U.S. $39.50; paper U.S. $14.50.

Hoverflies. 1985. By Francis S. Gilbert. Cambridge University Press, New York. 96 pp., illus. U.S. $16.95.

Insect communication. 1984. Edited by Trevor Lewis. Acadmic Press, Orlando, Florida. xviii + 414 pp., illus. U.S. $55.

International wildlife law: an analysis of international treaties concerned with the conservation of wildlife. 1985. By Simon Lyster. Grotius, Cambridge, England. xxiv + 470 pp., illus. Cloth U.S. $37; paper U.S. $17.50.

The mammals of the Southern Africa Subregion. 1983. By Reay H.N. Smithers. South Africa Reader's Choice, Capetown. xxii + 736 pp., illus. U.S. $75.

Managing forested lands for wildlife. 1984. Edited by Robert L. Hoover and Dale L. Wills. Colorado Division of Wildlife, Denver. xiii + 459 pp., illus.

Menaboni's birds. 1984. By Athos and Sara Menaboni. Clarkson Potter, New York. xvi + 156 pp., illus. U.S. $24.95.

Methods in marine zooplankton ecology. 1984. By Makoto Omori and Tsutomu Ikeda. Translated and revised from Japanese edition 1976. Wiley-Interscience, New York. xvi + 332 pp., illus. U.S. $44.95.

Nearctic avian migrants in the neotropics. 1983. By John H. Rappole et al. U.S. Fish and Wildlife Service (distributed by World Wildlife Fund, Washington). vi + 646 pp., illus.

The Nereidae (Polychaetous annelids) of the Chinese coast. 1985. By B. Wu, R. Sun, and D. Yang. Springer-Verlag, New York. c320 pp., illus. U.S. $79.50.

The North American grasshoppers, volume 2: Acrididae: Oedipodinae. 1984. By Daniel Otte. Harvard University Press, Cambridge. x + 366 pp., illus. + plates. U.S. $60.

*__Ocean birds: their breeding biology and behaviour.__ 1984. By Lars Lofgren. Croon Helm, Bechenham, England. 240 pp., illus. £18.95.

The track of the wild otter. 1984. By Hugh Miles. St. Martin's, New York. 160 pp., illus. U.S. $15.95.

Tropical zooplankton. 1984. Edited by H.J. Dumont and J.G. Tundisi. Junk (U.S. distributor Kluwer, Boston). x + 345 pp., illus. U.S. $84.

The tungara frog: a study in sexual selection and communication. 1985. By Michael J. Ryan. University of Chicago Press, Chicago. 224 pp., illus. Cloth U.S. $33; paper U.S. $14.95.

The understanding of animals. 1984. Edited by Georgina Ferry. Basil Blackwell, New York. xvi + 320 pp., illus. Cloth U.S. $19.95; paper U.S. $8.95.

†**Wasp farm.** 1985. By Howard Ensign Evans. Reissue of 1963 edition. Comstock (Cornell University Press), Ithaca. x + 178 pp., illus.

*__Wings along the Winnipeg: the birds of the Pinawa-Lac du Bonnet Region, Manitoba.__ 1983, 1985. By Peter Taylor. EcoSeries No. 2. Manitoba Naturalists Society, Winnipeg. 223 pp., illus.

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TABLE OF CONTENTS *(concluded)*

Mailing date of the previous issue (Volume 100, Number 1): 30 July 1986

THE CANADIAN FIELD-NATURALIST Volume 100, Number 2 1986

Articles

Notes

concluded on inside back cover

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Cover: Brant, *Branta bernicla*, photographed in June 1983 at Cambridge Bay, Victoria Island, Northwest Territories by C. M. Lok. *See* Lok and Vink pp. 315-318.

The Canadian Field-Naturalist

Volume 100, Number 3 July-September 1986

Birds at Cambridge Bay, Victoria Island, Northwest Territories, in 1983

C. M. Lok[1] and J. A. J. Vink[2]

[1]Prunuslaan 14, 3235 VL Rockanje, The Netherlands
[2]Aristoteleslaan 4, 3707 EL Zeist, The Netherlands

Lok, C. M., and J. A. J. Vink. 1986. Birds at Cambridge Bay, Victoria Island, Northwest Territories, in 1983. Canadian Field-Naturalist 100(3): 315–318.

During 300 man-hours of walking between 23 June and 6 July, 41 species were seen. The Merlin, *Falco columbarius*, and the Mountain Bluebird, *Sialia currucoides*, had not been recorded previously. Comparisons with detailed studies in 1960 and 1962 showed marked increases in Canada Geese, *Branta canadensis*, and Greater White-fronted Geese, *Anser albifrons*, while Brant, *Branta bernicla*, had almost disappeared.

Key Words: Avifaunal records, Victoria Island, Northwest Territories, Merlin, *Falco columbarius*, Mountain Bluebird, *Sialia currucoides*, Canada Goose, *Branta canadensis*, Greater White-fronted Goose, *Anser albifrons*, Brant, *Branta bernicla*.

In 1960 and 1962 an inventory of the birds of southeastern Victoria Island and adjacent small islands was made by Parmelee et al. (1967). Their account is very detailed, facilitating comparison. In the summer of 1983 we had the opportunity to observe birds in one of their main areas of study near Cambridge Bay. Sufficient data were collected to indicate changes in the status of a few species.

The study area was adjacent to the southern coast of Victoria Island between the settlement, Greiner Lake and Mount Pelly (Figure 1). The area is essentially flat, with countless ponds and lakes that form a labyrinth of fresh waters. Well-vegetated patches are found near these waters.

One of the lakes between Mount Pelly and Greiner Lake contained three islands that were very probably the three islands mentioned several times by Parmelee (1967). The wet areas are separated by barren stony ridges without much vegetation. The only high land is Mount Pelly, less than 300 m in elevation.

Methods

Data were gathered by both observers from 23 June to 6 July, during about 300 man-hours' walking. All observations were noted, except when obvious resightings of breeding pairs were involved. As some areas were visited repeatedly, a number of double counts could not be excluded.

However, the total number of each species of bird thus obtained can be used as an indication of their relative abundance. The clutch sizes of the geese and Sabine's Gull were verified on subsequent visits. Most other nests, however, were visited only once.

Results

A summary of our records is given in Table 1. Supplementary observations are given below, especially when the status of a species seems to have changed since the early 1960s.

Tundra Swan, *Cygnus columbianus*

A nest was located at the very top of a hill, 1 km from the nearest lake. In contrast, a previous year's nest was on the bank of that lake. Parmelee (1967) noted that this species nests "on islands and banks close to fresh water".

Canada Goose, *Branta canadensis*

Our observations strongly suggest that this species has increased in numbers since the early 1960s. Parmelee (1967) mentioned that the Canada Goose occurred throughout southeastern Victoria Island, but was only thinly distributed. They found 15 nests in the entire area they examined in 1960 and 1962. In spite of our limited coverage we found 19 nests. Almost every suitable small island in the area was occupied and our first nests were within a mile of the settlement. The lake with the three islands, which was

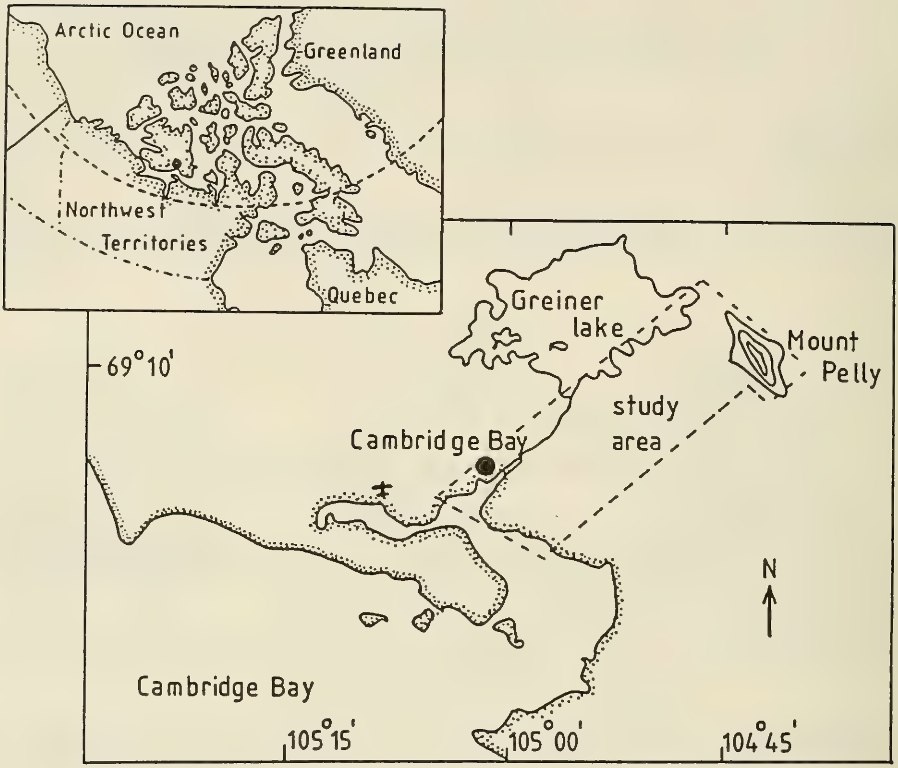

FIGURE 1. Area of our observations (dashed outline) near Cambridge Bay 1983.

not occupied by Canada Geese in the early 1960s, held two pairs, breeding about 50 m apart.

Brant, *Branta bernicla*

In 1983 the Brant was decidedly not "the commonest goose in the general vicinity of Cambridge Bay" as noted by Parmelee in 1960. They found it less abundant in 1962. We saw only 12 Brant, compared with 170 Canada Geese, and found only two nests. One nest was in a colony of Sabine's Gulls on one of the three islands mentioned above. In the 1960s the "three islands" contained as many as six nests and perhaps two dozen pairs nested in the surrounding marsh. The second nest was in a colony of Glaucous Gulls, about 10 km from the first nest. Parmelee mentioned that the nest site was seemingly identical to that of the Canada Goose, although the two species did not occupy the same pond. The occupation in 1983 by Canada Geese of two of the three islands formerly occupied by Brant confirms this similarity of nesting sites.

Greater White-fronted Goose, *Anser albifrons*

The status of the whitefront had also changed. In 1960 only one nest was found, six miles west of the settlement, though a few pairs were observed near Greiner Lake and Mount Pelly (Parmelee 1967). In 1983 we saw 130 whitefronts. We found five nests, all on dry slopes at 5 to 20 m from water. The nests were relatively difficult to locate, unlike those of the more conspicuous island-breeding Canada Goose, with the result that we probably found only a fraction of the nests present.

Red-breasted Merganser, *Mergus serrator*

On an islet also occupied by nesting Canada Geese, Arctic Terns, Sabine's Gulls and Oldsquaws, we flushed a female merganser from a nest containing six merganser eggs and four eggs of the Oldsquaw. Another Oldsquaw nest was on the same islet.

Merlin, *Falco columbarius*

A female was hunting in the settlement on 6 July.

Lesser Golden-Plover, *Pluvialis dominica* and Black-bellied Plover, *Pluvialis squatarola*

In the early 1960s the Black-bellied Plover bred abundantly in the Cambridge Bay area, where it was

TABLE 1. Forty-one species of birds seen near Cambridge Bay, 23 June to 6 July 1983, with clutch sizes in nests found.

Species		I	II	Clutch sizes
Red-throated Loon	*Gavia stellata*	3	1	1×1
Arctic Loon	*Gavia arctica*	14	3	2×2
Yellow-billed Loon	*Gavia adamsii*	5	—	
Tundra Swan	*Cygnus columbianus*	48	1	1×3
Greater White-fronted Goose	*Anser albifrons*	130	5	1×2; 2×3; 2×5
(Black) Brant	*Branta bernicla*	12	2	1×5
Canada Goose	*Branta canadensis*	170	19	7×4; 1×5; 1×6
Northern Pintail	*Anas acuta*	14	—	
Common Eider	*Somateria mollissima*	12	—	
King Eider	*Somateria spectabilis*	340	3	1×2; 1×3; 1×5
Oldsquaw	*Clangula hyemalis*	260	2	1×4*; 1×7
Red-breasted Merganser	*Mergus serrator*	14	1	1×6
Rough-legged Hawk	*Buteo lagopus*	6	1	1×3
Merlin	*Falco columbarius*	1	—	
Peregrine Falcon	*Falco peregrinus*	1	—	
Rock Ptarmigan	*Lagopus mutus*	4	—	
Black-bellied Plover	*Pluvialis squatarola*	60	1	1×4
Lesser Golden-Plover	*Pluvialis dominica*	140	2	2×4
Semipalmated Plover	*Charadrius semipalmatus*	10	1	1×4
Ruddy Turnstone	*Arenaria interpres*	75	1	1×4
Semipalmated Sandpiper	*Calidris pusilla*	210	11	1×3; 10×4
Baird's Sandpiper	*Calidris bairdii*	110	10	10×4
Pectoral Sandpiper	*Calidris melanotos*	70	6	6×4
Stilt Sandpiper	*Calidris himantopus*	120	2	2×4
Buff-breasted Sandpiper	*Tryngites subruficollis*	1	—	
Red-necked Phalarope	*Phalaropus lobatus*	3	—	
Red Phalarope	*Phalaropus fulicaria*	175	10	1×3; 9×4
Pomarine Jaeger	*Stercorarius pomarinus*	6	—	
Parasitic Jaeger	*Stercorarius parasiticus*	26	2	1×2
Long-tailed Jaeger	*Stercorarius longicaudus*	72	3	1×1; 1×2
Thayer's Gull	*Larus thayeri*	9	—	
Glaucous Gull	*Larus hyperboreus*	170	2	
Sabine's Gull	*Xema sabini*	140	21	3×1; 3×2; 2×3
Arctic Tern	*Sterna paradisaea*	160	13	1×1; 2×2
Horned Lark	*Eremophila alpestris*	85	1	1×3
Common Raven	*Corvus corax*	1	—	
Mountain Bluebird	*Sialia currucoides*	1	—	
Water Pipit	*Anthus spinoletta*	12	—	
Lapland Longspur	*Calcarius lapponicus*	++	18	2×4; 11×5; 4×6; 1×7
Snow Bunting	*Plectrophenax nivalis*	70	—	
Redpoll	*Carduelis sp.*	3	—	

I—total number of birds observed. II—number of nests found.
*—in nest of Red-breasted Merganser.
++—very common.

somewhat commoner than the Lesser Golden Plover near the coast and decidedly commoner further inland. The densities were estimated to be one to two pairs of Black-bellied Plovers and about one pair of Golden Plovers per square mile (Parmelee 1967). Our observation of 140 Lesser Golden Plovers and only 60 Black-bellied Plovers suggests that the status of at least one of the two species has changed.

Mountain Bluebird, *Sialia currucoides*

A sky-blue male was hovering near a rocky outcrop at the very top of Mount Pelly on 28 June.

Discussion

In total we observed 41 species, two of them to our knowledge new to Victoria Island: Merlin and Mountain Bluebird. Both are clearly extralimital vagrants. Our breeding record of the Red-breasted Merganser seems to be the first proof of breeding for the Island. Breeding of this species was already assumed, based on two observations of one and two birds, respectively, in 1960 and on two birds secured in 1962 which were presumably a mated pair (Godfrey 1966; Parmelee 1967).

When comparing our observations from a single season visit with the findings of Parmelee (1967), several apparent changes can be indicated. Some of these can be explained as the year-by-year fluctuations in numbers which occur frequently for arctic-nesting species. Thus the absence of Snowy Owls and Pomarine Jaegers was probably due to the scarcity of lemmings in 1983 (we only observed one lemming).

On the other hand, the striking change in numbers of the three species of geese suggests a real change in status: the Brant had almost disappeared from the area, whereas both Canada and Greater White-fronted geese had clearly increased. The increase of the White-fronted Goose in the area reflects the steady increase in the total number of central arctic white-fronts found on the wintering grounds (Ogilvie 1978).

The increase of the Canada Goose coincides with a considerable increase in the Tallgrass Prairie population in recent years. This group is largely made up of *B. c. hutchinsii* from the eastern part of the range, which includes Victoria Island (Owen 1980). In contrast, the Brant had markedly declined. The marsh between Mount Pelly and Greiner Lake in which about 30 pairs of Brant had nested in 1960 contained mainly Canada Geese and White-fronted Geese in 1983, with only a single pair of Brant. The Canada Goose occupied almost every suitable small island, including at least two islands previously occupied by Brant. Similarly on Spitsbergen a decline of the Pale-bellied Brant, *B. bernicla hrota*, has coincided with the increase in numbers and expansion of range of the Barnacle Goose, *B. leucopsis*, which selects the same islands for breeding (Owen 1980). Both the *hutchinsii* Canada Goose, one of the smallest forms of that species (1600 – 2600 g) and the Barnacle Goose (1200 – 2500 g) are much heavier than the Brant (800 – 1800 g) and may well be able to displace this species from its nesting sites.

The clutch sizes recorded in the final column of Table 1 mostly involve very small samples, and are included chiefly because information on some species is very scarce. In three cases, the clutches we found in 1983 were appreciably smaller than those found in 1960 by Parmelee (1967): Canada Goose 5.5 ± 0.5 (n = 6) in 1960, 4.33 ± 0.07 in 1983; Sabine's Gull 2.67 ± 0.53 (n = 34) in 1960, 1.88 ± 0.78 in 1983; and Lapland Longspur 5.40 ± 0.74 (n = 48) in 1960, 5.22 ± 0.73 in 1983.

Our limited coverage of Victoria Island during a short period does not allow a detailed discussion of the status of the other birds. In general we conclude that the area still is a "bird paradise," as reported in the early 1960s (Waters 1961; Parmelee 1967).

Acknowledgments

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Habitat use by Mountain Goats, *Oreamnos americanus*, on the Eastern Slopes Region of the Rocky Mountains at Mount Hamell, Alberta

IRMGARD VON ELSNER-SCHACK

Elmarshausen, 3549 Wolfhagen, West Germany

von Elsner-Schack, Irmgard. 1986. Habitat use by Mountain Goats, *Oreamnos americanus*, on the eastern slopes region of the Rocky Mountains at Mount Hamell, Alberta. Canadian Field-Naturalist 100(3): 319–324.

This study demonstrates how Mountain Goats use their habitat with respect to food and security. The study area is part of the eastern slopes region of the Rocky Mountains in Alberta and is characterized by cold winters with low precipitation. Mountain Goat habitat here consists mainly of grassy slopes, gravel, rock, and spruce and aspen forests. The results are based on 2672 observations collected between sunrise and sunset during May and June 1981. Most animals were seen in pairs, but group size varied from 1 to 47 animals. Changes in social organization are shown by using the median herd size as an index. Habitat use is evaluated for rock, cliffs, gravel and grass slopes. The group size and activity of Mountain Goats were correlated to these three habitat types. Habitat selection, food value and security were graphed on a rock-to-grass continuum.

Key Words: Mountain Goats, *Oreamnos americanus*, habitat use, Rocky Mountains, Alberta.

In choosing their habitats, Rocky Mountain Goats (*Oreamnos americanus*) must balance their conflicting needs for security and food. Mountain Goats find superior food resources in open, grassy meadows where they are most vulnerable to predation. By contrast, security is highest in the cliffs and broken rocks where food is relatively scarce.

Habitat use by Mountain Goats has frequently been studied in the United States and in Canada. A study considering the strategy of resource use by Mountain Goats in Alberta (McFetridge 1977) documents the importance of security and forage for nursery groups. The manner in which habitat is used appears to be influenced by sociobiological factors as well.

This study examined habitat use by Mountain Goats to gain insight into the criteria used in habitat choice. It is hypothesized that large herds form to maximize security on grassy slopes where they use superior food resources. If goats seek security in large herds as well as on cliffs, then the frequency of rock occupation and group size ought to be inversely related. Large herds could be expected to move a greater distance from escape terrain than do small herds.

Study Area

The study was conducted on Mount Hamell, Alberta (53°58′N, 119°13′W) on the west side of Smokey River, about three kilometers north of Grande Cache on the eastern slopes of the Rocky Mountains. The data of McFetridge (1977) were obtained from the same population. Information about the history of this population, the physical characteristics, behaviour, food habits, habitat requirements and productivity is given by Kerr (1965).

Elevations range from 914 m at the river to 2134 m at the top of Mount Hamell. The main goat habitat (Figure 1) is located on the eastern slopes of the

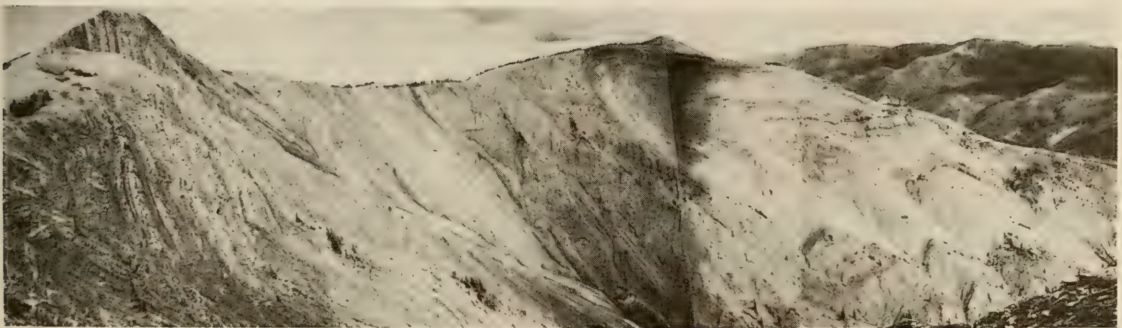

FIGURE 1. Study area. Mount Hamell, left, and slopes down to Hells Creek. Most observations were taken from the area shown in the picture.

mountain and covers approximately 16 km². The climate of the area is continental, with cold winters and warm summers. Precipitation is relatively low; most of it falls as rain during the summer. Frost and snow may occur at any time of the year.

The vegetation varies with topography and exposure. Grassy slopes, ridges and alpine meadows are interspersed with aspen (*Populus tremuloides*), dense thickets of alder (*Alnus crispa*) and spruce (*Picea engelmanii* and *P. glauca*). Shale slopes, cliffs and canyons occur below 1100 m. Southwest and northeast exposures grade downwards from a grassy alpine cover at high altitudes through an alpine-fir-aspen community to a dense evergreen forest of White Spruce at low levels. Northeast to northwest exposures support White Spruce and Alpine Fir (*Abies lasiocarpa*) communities. The upper 200 m of all exposures are covered by an alpine grass-forb community (Moss 1955). Much of the grassland results from past fires. These burns show very little regeneration of conifers. Effective fire suppression in recent years has resulted in the lack of new grassland development. The only predator actually observed on the study area was the Golden Eagle (*Aquila chrysaetos*) but tracks of Grizzly Bear (*Ursus arctos*) and Wolf (*Canis lupus*) were noted.

Materials and Methods

For field observations, field glasses (10×40) and a spotting telescope (35×70) were used. Data were recorded on a tape recorder.

The field work was carried out during five weeks in May and June 1981. Data were primarily recorded from a single point which offered a good view of most of the habitat used by goats. Whenever the area was free of clouds and fog, data were collected between sunrise and sunset at half hour intervals. The following information was recorded for each group of animals observed: time, herd size, sex and age of animals within the group, activity, and vegetation type. A total of 2672 individual observations were made. I recorded sex and age of animals only if they could be determined with reasonable certainty. Standing animals were recorded as "active", whereas bedded ones were considered "inactive" or resting.

Results

Group size

The distribution of observed herd sizes is presented in Figure 2. Most animals are found in groups of two, primarily females with kids. The largest observed herd contained 47 animals (22 June), about half of the population. The change in herd size over time is presented in Figure 3, using the median of herd sizes as an index.

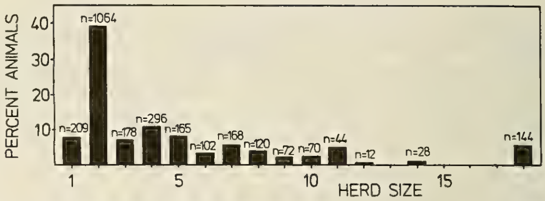

FIGURE 2. Observed herd sizes. Mountain Goats were mostly seen in pairs.

On 20 May when the first newborn kid was seen, the median herd size observed was 17 animals. As kidding progressed median herd sizes decreased. For several days after the initiation of kidding many animals were observed solitary and in mother-kid combinations. About a week after the first kid was seen, the median herd size increased again.

Kidding of Mountain Goats begins towards the end of May and lasts until June (Rideout 1978). In Canada De Bock (1970) observed the first kid on May 21 in the Kootenays. My first observation of a newly born kid was on May 20.

Habitat use

To evaluate habitat use, the Mountain Goat range on Mount Hamell was divided into three habitat types: rock, gravel, and grass. The distribution of animals observed in each habitat type during four periods in May and June is presented in Figure 4. Apparently grass is most important. During parturition, rock has its highest use; afterwards its use decreases and the gravel cover type is used more frequently.

Herd size and activity seem to play a role in habitat choice. Figure 5 shows that large active herds (more than four animals) spend most of their time in grassy areas and none at all in the rocks. By contrast, large inactive herds spend most of their time in the rocks and very little in grassy areas. Figure 6 shows important differences when small groups are considered (four or fewer animals). Small active groups spend equal amounts of time in grass and gravel but little in rocks. Small resting groups spend most of their time in gravel and approximately equal amounts of time in rocks and grassy areas. Inactive large groups show a preference for rock over gravel and grass (Figure 7), while active large groups preferred grass. They moved less into areas of gravel and not at all into rocks.

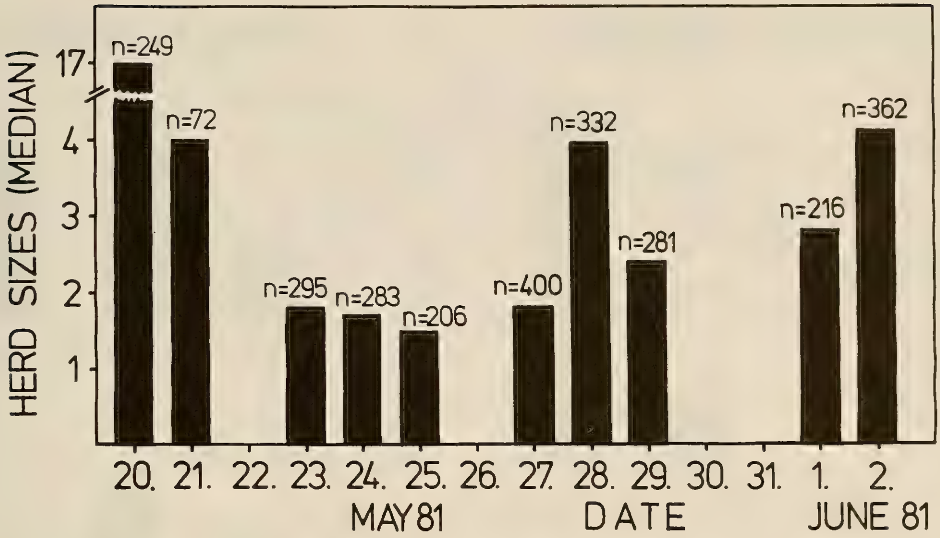

FIGURE 3. Change in median herd size during late May and early June, beginning with date on which first kid was observed.

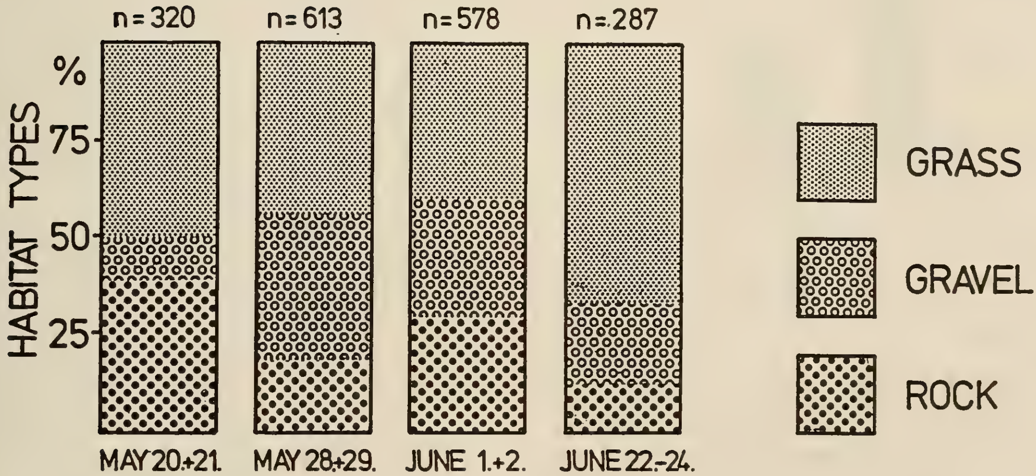

FIGURE 4. Distribution of Mountain Goats over three habitat types for different periods. Each period contains at least 287 observations of individual animals. The use of grasslands increases some time after kidding.

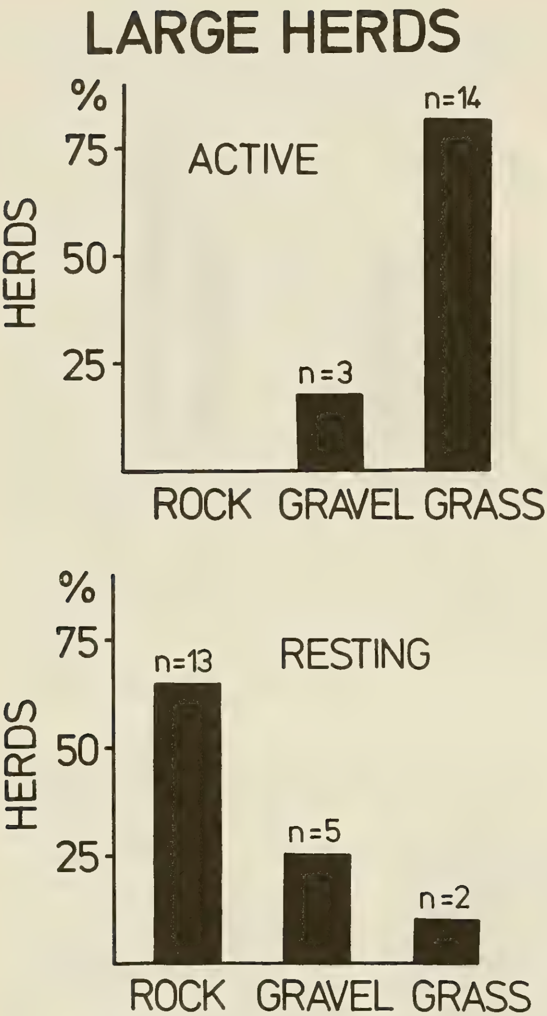

FIGURE 5. Habitat use of large herds (more than four animals), classified according to activity.

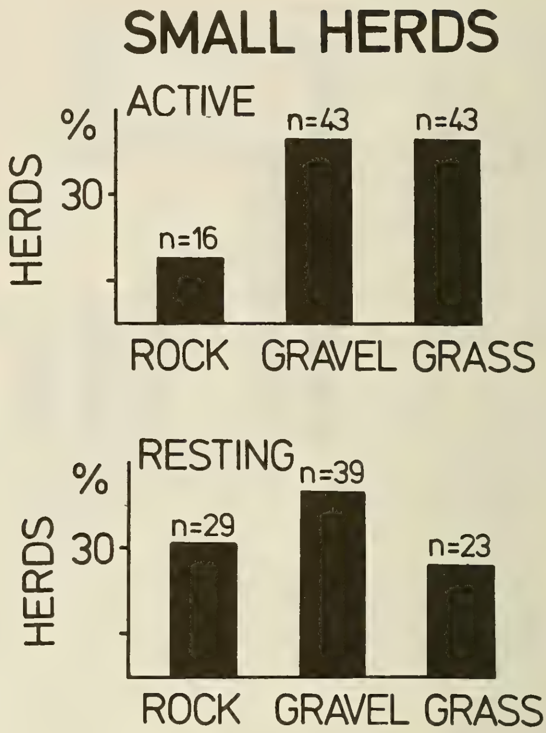

FIGURE 6. Habitat use of small herds (four or less animals), classified according to activity.

Discussion

Habitat types must fulfil at least two basic requirements of animals: they must provide both food and safety. The data presented provide insight into how Mountain Goats balance these two requirements during and after the kidding season. Other factors, such as energy yield and patchiness of home range or social behaviour, were not considered in this study.

The x-axis of Figure 8 represents habitat as a continuum from rock to grass, in which food value rises with increasing percentages of grass and security rises with increasing percentages of rock. A schematic curve for numbers of large groups shows use of more productive habitat types at the expense of security. The largest percentage of animals in small groups stays in the gravel cover type, which does not provide the best security, but is close to escape terrain and grass; this probably represents a compromise in habitat selection. Thus, small groups do not have to move far from feeding to resting places.

Availability of certain habitat types seems to exert a limiting influence on group size. As Wilson (1975: 135) indicates, group size is also a function of the energy yield of the home range. However, comparison of group size in my own observations with those taken by other authors is not possible because several authors (Bailey 1977; McFetridge 1977) present only mean values for the number of animals in a group.

To date, most studies show that habitat use by Mountain Goats is limited to areas close to rock cover. McFetridge (1977) states that the rock and gravel cover type receives greatest use and Chadwick (1977) found 93 percent of resting goats among rocks. This limitation is also supported by my observations which show that small groups use gravel and rock cover types to a greater extent than large groups.

The primary objective in habitat use by Mountain

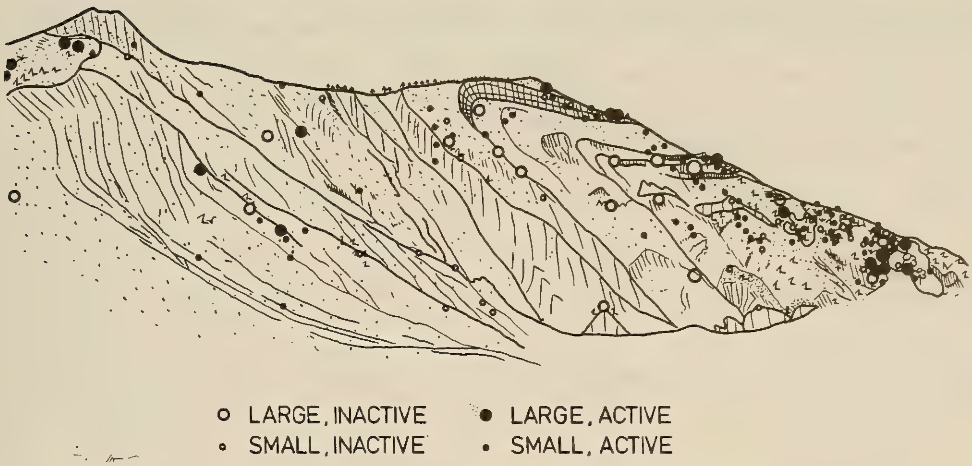

FIGURE 7. Distribution of Mountain Goats in the study area. Large dots are herds of more than four animals. Small dots represent herds with fewer animals. Solid dots show mostly active herds, open circles mostly inactive herds.

Goats is security. Also, within close range of escape terrain, only large groups use the most unsafe habitat type (grass) while foraging. Here group size may increase security. However, the data indicate that even when surrounded by a large group, individuals do not feel secure enough to rest in grassy areas. Under specific situations security does seem to be higher in large groups, but group size does not compensate for the security provided by habitat types.

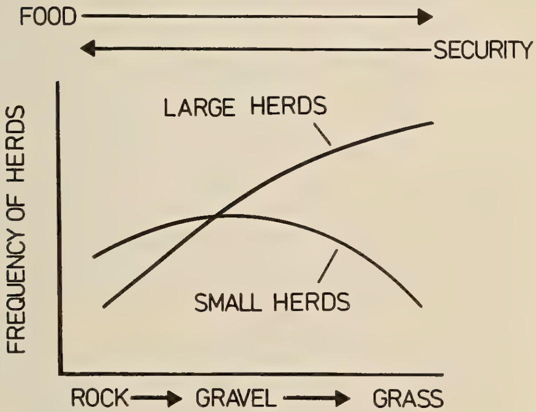

FIGURE 8. Observed habitat selection, food value and security on a rock-grass continuum. Large herds distinctly shift habitat types from food to security. In small herds this shift is not as pronounced. Most of the small herds prefer habitat types intermediate between food and security values (i.e. gravel).

Acknowledgments

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The Glacial Eelpout, *Lycodes frigidus*, from the Arctic Canadian Basin, New to the Canadian Ichthyofauna

N. J. PROUSE[1] and DON E. MCALLISTER[2]

[1]Marine Ecology Laboratory, Bedford Institute of Oceanography, Department of Fisheries and Oceans, Dartmouth, Nova Scotia B2Y 4A2

[2]Ichthyology Section, National Museum of Natural Sciences, Ottawa, Ontario K1A 0M8

Prouse, N. J., and Don E. McAllister. 1986. The Glacial Eelpout, *Lycodes frigidus*, from the Arctic Canadian Basin, new to the Canadian ichthyofauna. Canadian Field-Naturalist 100(3): 325–329.

Sampling at Canadian drifting ice station CESAR in the Canadian sector of the Arctic Ocean, 85°48′26.8″N, 110°43′39.3″W, produced the first Canadian record of *Lycodes frigidus* Collett, 1879. The specimen was caught at a depth of 2075 metres, -0.37°C, and a salinity of about 35.00 ‰. The new English vernacular, Glacial Eelpout, is suggested as a replacement for the former common name, coldwater eelpout, which would apply to almost any eelpout.

Key Words: Glacial Eelpout, *Lycodes frigidus*, Arctic Canadian Basin, station, CESAR, coldwater eelpout.

The few ichthyological collections that have been made in depths greater than 300 m in the Canadian Arctic have revealed several species of fishes new to Canada, or have contributed significant range extensions.

Sampling at Canadian drifting ice station CESAR in the Canadian Sector of the Arctic Ocean, approximately 350 km south of the North Pole and about 550 km northwest of Ellesmere Island, produced a specimen of the Glacial Eelpout, *Lycodes frigidus* Collett, 1879 (Figure 1). This species was previously unknown from the Canadian ichthyofauna (McAllister et al. 1981; D. E. McAllister. List of the fishes of Canada. Unpublished manuscript). This paper describes the specimen and compares it with other material, and discusses its distributional significance. The format follows that already used by Able and McAllister (1980) and McAllister et al. (1981), as part of a project preliminary to a book on marine fishes of Arctic Canada.

The Glacial Eelpout was caught on cod jigs attached to baited Niskin bottles on a kevlar line using a hydraulic winch. The gear was lowered to 2075 m and retrieved after 7 hours deployment; retrieval took approximately 40 minutes. Two pork chops were attached to the cod jigs. The Glacial Eelpout was caught on the jig that resembled a large fluorescent worm. Since *Lycodes* are benthic fishes, lack a gas bladder, and since there is photographic evidence (see below) that this *Lycodes frigidus* is benthic, we assume that our specimen was caught on the bottom.

Family ZOARCIDAE

Subfamily LYCODINAE

Lycodes frigidus Collett, 1879 Glacial Eelpout

Figures 1 and 2 lycode glaciale

Synonymy

ORIGINAL DESCRIPTION

Lycodes frigidus Collett, 1879:45 (syntypes deposited at Zoological Museum, University of Oslo; Zoology Museum, Copenhagen; British Museum of Natural History, London; National Museum of Natural History, Paris; and U. S. National Museum, Washington, all from Norwegian Sea or off Spitsbergen, Norwegian North Atlantic Expedition, 1876-78, 475-2438 m; date of publication 1879 *fide* Nielsen 1974; not 1878 *auctorum*).

CANADIAN ARCTIC RECORDS

No previous records.

SUPPLEMENTARY REFERENCES

Lycodes frigidus, Collett 1880: 96-103, plate III, figures 23,24 (description, distribution, depth); Jensen 1904: 22-25, plate V, figures 1a,b (synonymy, description, depth); Andriashev 1954: 302-305 (324-326 in translation), figure 172 (synonymy, description, distribution, life history); Andriashev 1964: 374-375 (description, distribution); Pethon 1969: 11-12 (syntypes at Zoology Museum, University of Oslo; Zoology Museum, University of Copenhagen; Zoology Museum, University of Bergen); Nielsen 1974: 77 (syntypes in Zoology Museum, University of Copenhagen); Tsinovsky 1980: 215-216 (description, distribution, depth); McAllister et al. 1981: 823, 829-830 (key, synonymy, diagnosis, description, taxonomy, distribution, depth).

Etymology — species name from the Latin *frigidus* for cold or cool, referring to the temperature of the waters in which this species is found, usually below 0°C.

Diagnosis

Differs from other *Lycodes* in Arctic Canada by the very small scales, about 42 to 48 in irregular longitudinal series on the body at a level with the anus; body color monotone, greyish or brownish; lateral line complete, ventrolateral in position; vertebrae 103-107; anal rays 85-90, including half of the caudal fin rays.

Description

MERISTICS

Data for the 477 mm TL (Total Length) Canadian Basin specimen are followed [in brackets] by counts from Jensen (1904) for Norwegian Sea material.

D + 1/2 C ca. 99 [99-104]
A + 1/2 C ca. 86 [85-90]
C ca. 10
P 19 [19-21]
Br 6
GR 3 + 12 = 15
Abd. vert. 22 [21-22]
Caud. vert. 82 [81-85]
Tot. vert. 104 [103-107]
Pyl. caeca 2

Head — Head moderate, length 27.0% total length (TL) [23.4-27.6 in adults, 23.0-24.6% in young], scaleless. Snout gently convex, tip evenly rounded, length 9.8% TL and 36.3% of head length, slightly overhanging upper jaw. Orbit large, ovoid, length 3.9% TL, 14.6% of head length. Jaws moderate, reaching to below the middle of the orbit. Mental crests obsolescent. About 19 moderate, sharp teeth in premaxilla in two rows anteriorly, one row posteriorly; lower jaw with 35 teeth in double row anteriorly, single row posteriorly. Vomer with 6 relatively large, conical teeth. Each palatine bone with single row of about 15 large teeth. Sensory canal system on head opening through minute pores. Gill opening well developed, extending forward dorsally, creating well-developed posteriorly directed flap; ventrally extending in front of pelvic fin base; isthmus width narrow, comprising 4.0% TL.

Body — Body long and slender, depth at anal origin 14.8% TL [9.5-14.2 in adults, 8.0-9.6% in young]. Scales cover entire body except nape in front of dorsal fin and immediately posterior to opercular flap, and on base of the pectoral fin. Belly scaled anteriorly to the tips of the pelvic fin. About 48 irregular rows of scale across the body at the level of the anal fin origin. No scales on fins. Lateral line descending posteroventrally across the abdomen, then running along urosome to tip of tail just above the anal fin. Predorsal length 34.2% TL, pre-anus length 49.5% TL; premanal distance 45.9% TL [38.2-47.0%]. Pectoral fin moderate, ovoid, not emarginate, upper rays longest, comprising 13.9% TL. Pelvic fins short, 1.6% TL, with 3 rays each.

COLOUR

Collett (1880) reported fresh colour as uniformly dark reddish-grey or brownish-grey, with young individuals lighter than adults. Abdomen and branchiostegal membranes were reported to be bluish-black (Andriashev 1954). Underside of head was lighter than upper surface of body in a Chukchi Rise specimen (McAllister et al. 1981). Our Canadian Basin specimen, when caught and later when frozen, was an even brown colour intermediate between that of milk chocolate and dark chocolate. The peritoneum was dark brown.

SEXUAL DIMORPHISM

Jensen (1904) reported that males tend to have longer heads, 23.6-27.6% TL, as opposed to 22.4-25.2% in females, and longer snout-anus distances, 43.7-47.0% TL in males than in females, 38.2-45.6%, and in immature young where it is 38.8-43.1% TL.

SIZE

The Canadian Basin specimen is an adult male 477 mm TL and weighed 753.5 grams after being frozen and before preservation in formalin. Nizovtsev et al. (1976) reported the maximum known length of 690 mm TL; this fish weighed 1986 grams.

MATERIAL EXAMINED

From Arctic Canada

One specimen from the Canadian Basin, 477 mm TL, NMC83-0201, Canadian sector of Arctic Ocean in Canadian Basin at 85°48′26.8″N, 110°43′39.3″W, at 2075 m depth, 06 April 1983 (Figure 1).

Systematics

Andriashev (1954, 1964, 1973) summarized the confusion in the literature on *Lycodes frigidus*. Two closely related but distinct species, *Lycodes atlanticus* Jensen, known along the temperate Atlantic slope from off Ireland to Florida, and *Lycodes agulhensis*, from southern Africa off Agulhas Bank at 1400 m, have been wrongly ascribed to *Lycodes frigidus*, which appears to be confined to the Arctic Ocean.

The vernacular, Coldwater Eelpout for *Lycodes frigidus*, was used by McAllister et al. (1981). As almost all eelpouts live in cold water, viz. below 10°C, we propose that the adjective glacial be substituted for coldwater, in reference to the typical thermal regime inhabited by this fish (below 0°C).

FIGURE 1. Photograph of 477 mm TL (Total Length) specimen of *Lycodes frigidus*, catalogue number NMC83-0201, captured at a depth of 2075 m in the Canadian Basin from Canadian Project CESAR polar ice station.

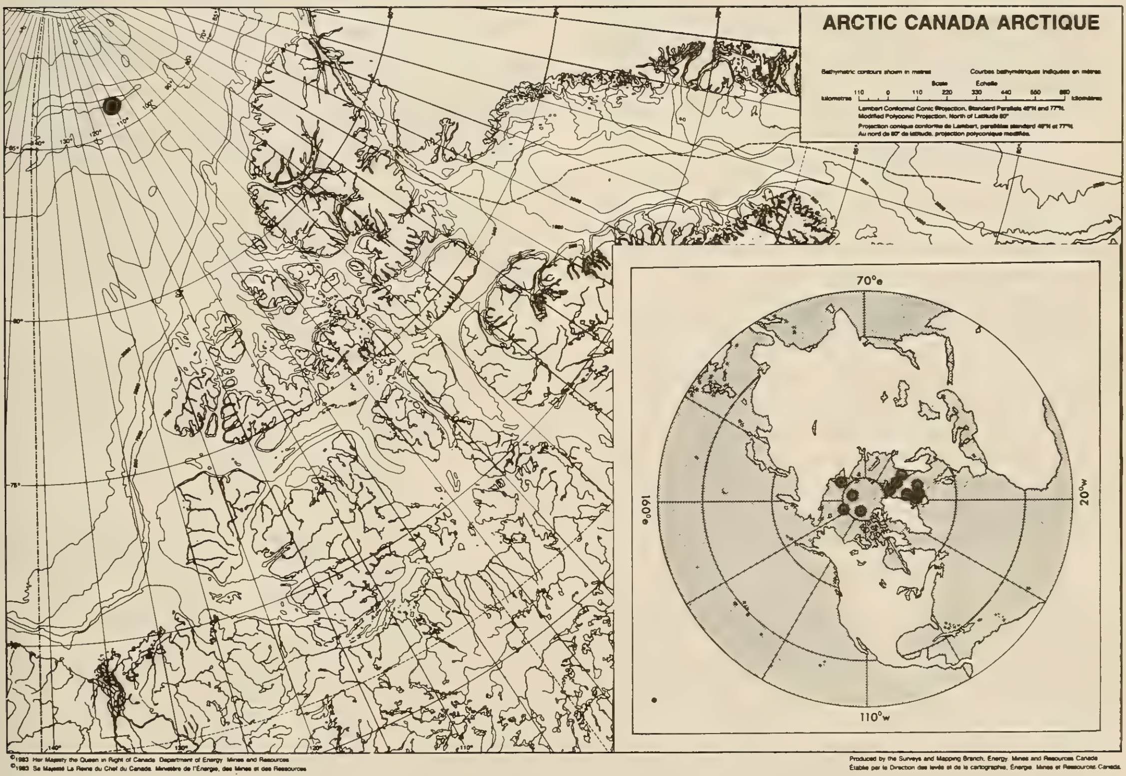

FIGURE 2. Canadian record of the Glacial Eelpout, *Lycodes frigidus*, with inset showing world distribution.

Distribution

The range of *Lycodes frigidus* (see Figure 2) includes the Norwegian and Greenland seas, the Eurasian Arctic Basin, the northern part of the Laptev Sea, the Chukchi Rise in the northern Chukchi Sea, and the northern Canadian Basin. The scattered nature of its known distribution is most likely due more to the paucity of samples in deep Arctic waters than to a patchy distribution.

Habitat

Our specimen was probably caught at a depth of 2075 m on a soft mud bottom, where the temperature was -0.37°C and the salinity was approximately 35.00 ‰. This species is known from depths between 475 and 2750 m (possibly to 3000 m), but usually occurs between 1000 and 1300 m (Andriashev 1954). It has almost always been encountered at temperatures below 0°C, usually from -0.6 to -1.6°C. The species is probably benthic on mud bottoms — McAllister et al. (1981) refer to a published photo of a specimen on the bottom at a depth of 2000 m that is almost certainly this species. In deeper water collections in the Norwegian Sea, *Lycodes frigidus* was caught at all stations between 1400 and 2300 m, with the largest catches between 1660 and 1910 m (Nizovtsev et al. 1976).

Reproduction

According to Andriashev (1954), spawning apparently occurs at great depths where both adults and young are found. Jensen (1904) examined a female about 500 mm TL with an ovary 84 mm by 47 mm containing 500 eggs 7 mm in diameter. This female was captured on 29 August 1902, north of the Faeroes (63°13′N, 6°32′W) at a depth of 1783 m and a temperature of -0.51°C. In a 515 mm TL male taken by the Ingolf Expedition the testes were 65 mm long and 10 mm broad (Jensen 1904).

Males of *Lycodes frigidus* trawled at depths of 1400-2300 m in the Norwegian Sea were in maturity stages VII to II, and females VI to II. The largest male, 690 mm TL, had testes in maturity stage II (Nizovtsev et al. 1976). Data suggest fall or winter spawning.

Food

Andriashev (1954) reported in the stomachs of *Lycodes frigidus* various deepwater Crustacea (*Mesidothea megalura, Eurycope cornuta, Astacilla granulata, Pasiphaea tarda, Phoxus crenulatus, Padocerus assimilis, Themisto libelula, Hymenodora galcialis*), and more rarely, remnants of fishes, ophiuroids, cephalopods, molluscs, sipunculids, and other representatives of the Arctic abyssal fauna. The Canadian specimen contained small red bits of crustaceans consisting mostly of a decapod shrimp and one part of an epibenthic male lisianassid amphipod.

Tsinovsky (1980) reported catching one 413 mm TL specimen at 83°15′N, 151°00′W at a depth of 2505 m, on a hook with meat bait in 6 months of fishing using set lines with 50 hooks baited with meat or fish. The species appears quite hardy; Tsinovsky's specimen was hauled up to the surface alive from a depth of 2505 m.

Predators

We have no information concerning predators.

Parasites

We have no information concerning parasites.

Discussion

The meristic, morphometric and colour characters are in agreement with those described by Jensen (1904), Andriashev (1954) and Tsinovsky (1980) in the major details. There does not seem to be any question that the specimen can be identified as *Lycodes frigidus*.

The very few collections from the deeper waters of the Canadian Basin off the North Slope of Alaska (McAllister 1975) or in the eastern Beaufort Sea (McAllister et al. 1981) have revealed the presence of undescribed species and range extensions of up to several thousand kilometres. Eleven benthic fish species are now known from the Canadian Basin at depths of 300 m or more. The others are Rajidae: *Raja* sp.; Zoarcidae: *Lycodes eudipleurostictus, Lycodes pallidus, Lycodes rossi, Lycodes sagittarius, Lycodes seminudus, Lycodes squamiventer*; Cottidae: *Icelus bicornis*; Psychrolutidae: *Cottunculus sadko*; Pleuronectidae: *Reinhardtius hippoglossoides*. Four other species probably occur in midwater over these depths – Gadidae: *Boreogadus saida, Arctogadus glacialis*; Liparidae: *Liparis fabricii* (Able and McAllister 1980). According to Dr. M. Eric Anderson, *Paraliparis bathybius* and *Rhodichthys regina* also may be added to these.

The few samples suggest that the ichthyofauna under the permanent polar ice pack is richer than might be expected. Additional sampling is likely to reveal more species of fishes, details of bathymetric and geographic distribution, food habits, and reproduction of one of the more poorly known fish faunas of the world. We do not know whether these fishes, living under conditions of six months of darkness in the polar winter and at depths below photosynthesis in summer, grow very slowly and attain great ages. We do not know details of reproduction of most of the species. Nor do we know

population densities. Clearly there is a promising field of biological research lying under the semipermanent platform of two or more metres of ice.

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A Survey of Some Perennial Vascular Plant Species Native to Alberta for Occurrence of Mycorrhizal Fungi

RANDOLPH S. CURRAH and MARGARET VAN DYK

University of Alberta, Devonian Botanic Garden, Edmonton, Alberta T6G 2E1

Currah, Randolph S., and Margaret Van Dyk. 1986. A survey of some perennial vascular plant species native to Alberta for occurrence of mycorrhizal fungi. Canadian Field-Naturalist 100(3): 330–342.

Observations on mycorrhizal and other root-associated fungi are presented for 179 native vascular plant species collected from short grass prairie, parkland, montane, alpine, and boreal forest ecoregions of Alberta. Four types of root-associated fungi were recognized: vesicular arbuscular mycorrhizal fungi (VAM), dematiaceous fungi which formed extensive nets on the surfaces of roots (DSF), orchidaceous fungi found within the root cortical cells of Orchidaceae, and arbutoid mycorrhizal fungi. The majority of non-orchid species had VAM. Some plant families (Cruciferae, Chenopodiaceae, Equisetaceae) and most hydrophytes lacked root-associated fungi of any kind. Hemiparasitic Scrophulariaceae lacked VAM but some had DSF. Most alpine species displayed minimal infection by VAM but had well-developed DSF. Some perennial species of reputedly non-mycorrhizal families (Polygonaceae, Caryophyllaceae) demonstrated well-developed VAM associations.

Key Words: Mycorrhizal fungi, root-associated fungi, perennial, non-arborescent vascular plants, symbiosis, Alberta.

Records of the occurrence of mycorrhizal and other root-associated fungi in native plants of Canada have been made for some ferns and fern allies of southern Ontario (Berch and Kendrick 1982) and for some species of the boreal forest of northeastern Ontario (Malloch and Malloch 1981, 1982). There are few references to the occurrence of mycorrhizae in perennial, non-arborescent, vascular plant species of western Canada (Currah et al. 1982, 1983).

For species of economic importance, Maronek et al. (1981) and Menge (1983) have reviewed a number of controlled studies which have demonstrated that mycorrhizae can significantly improve nutrient uptake, increase resistance to water stress, improve growth in saline soils, and improve establishment and productivity of the host plant. In spite of the importance of these effects to the competitive abilities of green plants with mycorrhizae, ecological studies of native plants have virtually ignored the mycorrhizal component (e.g. Belsky and del Moral 1982; Grier and Ballard 1981). St. John and Coleman (1983), in a review of the significance of mycorrhizae to plant ecology, point out that although baseline information on mycorrhizae in native plants is rare, the symbiosis can be expected to play an important role in plant-plant and plant-microorganism competitions where resources are limiting. Because of the lack of confirmed observations on the occurrence of mycorrhizae in native plants of Alberta and because of the potential significance of such data to practical and theoretical projects involving native plants in natural and contrived situations, we examined the occurrence of root-associated fungi in 179 plant species native to alpine, montane, short grass prairie, boreal forest and parkland ecoregions of Alberta.

Materials and Methods

Collections used in this study were obtained from the following sites in Alberta (Figure 1). The ecoregion and several of the more obvious components of the flora of each site are listed along with a brief description of the soils. Site numbers correspond with those on Figure 1.

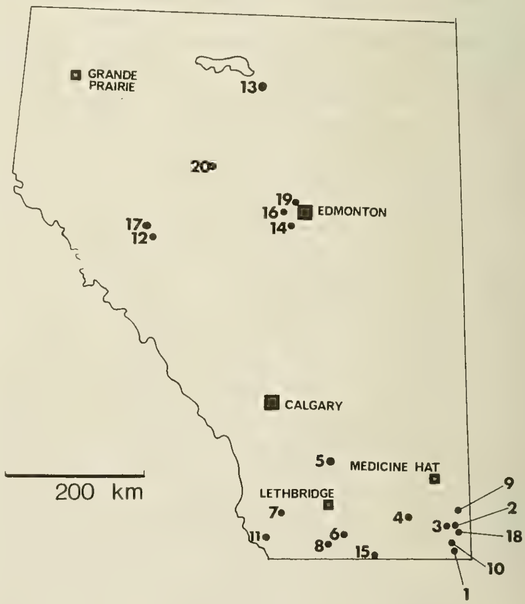

FIGURE 1. The province of Alberta south of 56° showing numbered sites from which root samples were collected.

(1) Cressday – Short grass prairie, *Bouteloua gracilis, Opuntia polyacantha, Artemisia cana*; sandy loams low in organic matter and high in gypsum.
(2) Elkwater – Short grass prairie, *Rosa* spp., *Amelanchier alnifolia, Potentilla fruticosa, Symphoricarpos occidentalis*; sandy loams.
(3) Bullshead – Short grass prairie, *Bouteloua gracilis, Stipa comata, Artemisia frigida*; sandy loams.
(4) Granlea – Short grass prairie, *Artemisia cana, Stipa comata, Hordeum jubatum*; sandy loams.
(5) Little Bow – Short grass prairie, *Rosa* spp., *Stipa comata* and *Bouteloua gracilis*; sandy loams.
(6) Milk River Ridge – Short grass prairie, *Bouteloua gracilis, Thermopsis rhombifolia, Astragalus bisulcatus*; alkaline loams.
(7) Summerview – Short grass prairie, *Juniperus horizontalis*, mixed grass species; sandy, dry and low in organic matter; many rocky outcrops.
(8) Jensen – Short grass prairie, *Bouteloua gracilis, Bromus inermis* and *Rosa* spp.; alkaline loams.
(9) Cypress View – Short grass prairie, *Bouteloua gracilis, Bromus inermis, Artemisia frigida*; soils coarse-textured and low in organic matter.
(10) Michel – Short grass prairie, *Juniperus horizontalis, Artemisia frigida, Chrysothamnus nauseosus*; sodic saline loams.
(11) Castle River – Montane, *Picea glauca, Rubus parviflorus*; organic loams.
(12) Cardinal River Divide – Alpine – a. seepage areas, vegetation of mixed forbs and grasses; soils organic. – b. *Betula glandulosa, Dryas* spp.; soils gravelly with some coarse organic detritus.
(13) Mitsue – Boreal forest, *Populus tremuloides, Picea glauca*; rich organic loams.
(14) Devonian Botanic Garden – Parkland – a. *Pinus banksiana, Populus tremuloides*; fine-textured (aeolian) sands. – b. *Salix* spp. in alkaline, sedge peat fens.
(15) Milk River – Short grass prairie, *Bouteloua gracilis, Stipa comata, Phlox hoodii*; coarse sands low in organic matter.
(16) Wagner Bog – Parkland – a. *Picea mariana, Sphagnum* spp. and feather mosses; moss and associated organic detritus. – b. *Campylium stellatum, Scorpidium scorpioides*; marls.
(17) Cadomin – Montane, *Antennaria rosea*; exposed, boulder field; coarse-textured gravels with little organic matter.
(18) Cypress Hills Provincial Park – Montane, *Picea glauca*; soils acid and high in organic matter.
(19) River Valley Road – Parkland, *Picea mariana*, feather mosses; marls with organic detritus from mosses.
(20) Carson Lake – Boreal forest, *Populus* spp.; soils organic and rich in leaf mold.

Root samples were obtained by digging up one or more plants of each species selected for study and carefully removing the adhering soil from the root system. In most cases only one population was sampled but for some species at least two populations were sampled. These species are indicated in Table 1 by an asterisk (*) at the appropriate site. Species indicated by "#" in Table 1 were sampled from the same populations (at site 6, Milk River Ridge) in June and September of 1983. The remaining species were sampled during July or August of 1981 and 1982. For each sample, ten or more healthy roots (rhizome segments were used in *Corallorhiza trifida*) were excised, fixed in FAA and transported to the laboratory where they were kept at 5°C until processed. Root segments 10-20 mm in length were washed with distilled water, cleared, stained (Phillips and Hayman 1970), and mounted in glycerine jelly. For species with deeply pigmented root epidermal cells it was necessary to clear samples in a 0.5% solution of sodium hypochlorite. For each collection, at least eight root segments were examined with the compound microscope. Voucher specimens for plant species examined are deposited in the Herbarium of the University of Alberta Devonian Botanic Garden. Nomenclature of vascular plants follows Packer (1983). No attempt was made to identify or quantify the fungus component of the associations.

With the exception of DSF, fungal associations were classified according to the definitions outlined in Moore-Landecker (1982). **1.** Vesicular arbuscular mycorrhizal fungi (VAM) were considered to be present when at least one of (a) arbuscules, "A" (dendritic branching at the terminus of a hypha within a host cell, Figure 6), or (b) vesicles, "V" (Figure 2) were present in the root cortex. Other hyphal configurations associated with VAM were coils ("C") of broad, aseptate hyphae (Figure 3), and irregular, sometimes lobed and branched, broad, aseptate hyphae ("H"). **2.** Septate, dematiaceous surface fungi ("DSF") with deeply melanized walls (Figure 5) adhered to the root epidermis, often forming reticulate masses on root surfaces. Clamp connections were frequently observed on these hyphae. **3.** Orchidaceous mycorrhizal fungi, "ORCH" (Figure 4), were present only in the root cells of orchids and consisted of coiled masses of slender, thin-walled, septate hyphae which often had clamp connections. **4.** Pigmented hyphae which were composed of short, broad, septate, irregularly lobed cells, formed a dense layer on root surfaces, and penetrated the cortex and cortical cells (Figure 7), were referred to as arbutoid mycorrhizae ("ARB"). Table 1 lists the occurrence of

TABLE 1. Occurrence of root-associated fungi in 179 plant species native to Alberta.

Taxa	Region (site)	Root-associated fungi[1]
Adoxaceae		
Adoxa moschatellina	boreal forest (13)	lacking
Alismataceae		
Sagittaria cuneata	boreal forest (13)	lacking
Apocynaceae		
Apocynum androsaemifolium	parkland (14a)	–, A, H, V
Araceae		
Calla palustris	parkland (14 pond)	lacking
Araliaceae		
Aralia nudicaulis	parkland (14a)	–, –, H, V
Asclepiadaceae		
Asclepias viridiflora	prairie (15)	–, A, H, –
Boraginaceae		
Lithospermum ruderale	prairie (2)	lacking
Mertensia paniculata ssp. *paniculata*	boreal forest (13)	C, A, H, V
Cactaceae		
Coryphantha vivipara#	prairie (5, 6*, 8)	C, A, H, V
Opuntia polyacantha	prairie (1)	–, A, H, V
Campanulaceae		
Campanula lasiocarpa	alpine (12b)	DSF
Campanula rotundifolia#	prairie (6, 8)	C, A, H, V
Caprifoliaceae		
Linnaea borealis ssp. *americana*	parkland (14a)	C, A, H, V +DSF
Caryophyllaceae		
Arenaria congesta var. *lithophila*	prairie (2)	–, –, H, V
Paronychia sessilifora#	prairie (2, 6*, 7, 8)	C, A, H, V
Silene acaulis	alpine (12b)	–, –, H, V, +DSF
Chenopodiaceae		
Atriplex nuttallii	prairie (1)	lacking
Salicornia europaea ssp. *rubra*	prairie (1)	lacking
Compositae		
Achillea millefolium ssp. *lanulosa#*	prairie (1, 6*, 8)	C, A, H, V
Agoseris glauca#	prairie (2, 6*, 8)	C, A, H, V
Antennaria rosea	montane (17)	C, A, H, V
Antennaria umbrinella	prairie (1)	lacking
Arnica cordifolia	alpine (12a)	C, A, H, V +DSF
Arnica fulgens	prairie (6)	C, A, H, V
Artemisia campestris ssp. *caudata*	prairie (6*, 8)	C, A, H, V
Artemisia cana	prairie (1)	C, –, H, V
Artemisia frigida#	prairie (2, 6, 8)	C, A, H, V
Artemisia ludoviciana var. *ludoviciana#*	prairie (6*, 8)	C, A, H, V
Aster ericoides ssp. *pansus#*	prairie (6*, 8, 9)	C, A, H, V
Aster hesperius	parkland (14a)	C, A, H, V
Aster laevis	prairie (6*, 8)	C, A, H, V
Balsamorhiza sagittata	montane (11)	C, A, H, V
Chrysothamnus nauseosus	prairie (1, 10)	–, A, H, V
Erigeron caespitosus#	prairie (6*, 8)	C, A, H, V
Erigeron peregrinus ssp. *callianthemus*	alpine (12a)	DSF
Gaillardia aristata#	prairie (2, 6, 8)	C, A, H, V
Grindelia squarrosa	prairie (1, 2, 6, 10*)	C, A, H, V
Gutierrezia sarothrae#	prairie (1, 2, 4, 6*, 8)	C, A, H, V
Haplopappus lanceolatus	prairie (1*, 10)	C, A, H, V

TABLE 1. Occurrence of root-associated fungi in 179 plant species native to Alberta (*continued*).

Taxa	Region (site)	Root-associated fungi[1]
Haplopappus spinulosus#	prairie (6, 8)	C, A, H, V
Helianthus subrhomboideus	prairie (2)	–, A, H, V
Helianthus nuttalli	prairie (1, 10)	C, A, H, V
Heterotheca villosa var. *hispida#*	prairie (1, 6*, 8)	C, A, H, V
Hymenopappus filifolius	prairie (6)	C, A, H, V
Hymenoxys acaulis#	prairie (6, 8)	C, A, H, V
Hymenoxys richardsonii#	prairie (6*, 8)	C, A, H, V
Liatris punctata	prairie (5, 6*, 8)	C, A, H, V
Lygodesmia juncea#	prairie (2, 6, 8)	C, A, H, V
Machaeranthera grindelioides#	prairie (6*, 8, 15)	C, A, H, –
Petasites nivalis	alpine (12a)	DSF
Petasites palmatus	parkland (14a)	C, A, H, V
Petasites sagittatus	parkland (14b)	–, –, H, V
Ratibida columnifera#	prairie (2, 6, 8)	C, A, H, V
Senecio canus#	prairie (6*, 8, 9)	C, A, H, V
Senecio triangularis	alpine (12a)	DSF
Solidago mollis	prairie (2)	C, –, H, V
Solidago rigida var. *humilis*	prairie (2)	C, –, H, V
Townsendia exscapa	prairie (8)	C, A, H, V
Cornaceae		
Cornus canadensis	parkland (14a)	–, –, H, V +DSF
Crassulaceae		
Sedum lanceolatum	montane (11)	–, A, H, V
Cruciferae		
Arabis holboellii	prairie (15)	lacking
Draba oligosperma	prairie (7)	lacking
Physaria didymocarpa	prairie (7)	lacking
Smelowskia calycina var. *americana*	alpine (12b)	lacking
Equisetaceae		
Equisetum arvense	parkland (14a)	lacking
Esquisetum fluviatile	parkland (14b)	lacking
Equisetum hyemale	parkland (14a)	lacking
Equisetum scirpoides	alpine (12a)	DSF
Ericaceae		
Arctostaphylos rubra	alpine (12b)	DSF
Gentianaceae		
Gentiana glauca	alpine (12a)	DSF
Gentiana prostrata	alpine (12b)	DSF
Gentianella propinqua	alpine (12b)	DSF
Geraniaceae		
Geranium viscosissimum#	prairie (2, 6*, 8)	C, A, H, V
Gramineae		
Oryzopsis asperifolia	parkland (14a)	C, A, H, V
Hydrophyllaceae		
Phacelia sericea	montane (17)	lacking
Iridaceae		
Sisyrinchium montanum#	prairie (6, 7)	C, A, H, –
Labiatae		
Monarda fistulosa var. *menthifolia*	prairie (2)	C, A, H, V
Leguminosae		
Astragalus alpinus	alpine (12b)	DSF
Astragalus bisulcatus#	prairie (6, 8)	C, A, H, V
Astragalus crassicarpus#	prairie (6)	C, A, H, V

TABLE 1. Occurrence of root-associated fungi in 179 plant species native to Alberta (*continued*).

Taxa	Region (site)	Root-associated fungi[1]
Astragalus drummondii#	prairie (6*, 8)	C, A, H, V
Astragalus gilviflorus	prairie (2, 6*, 7, 8, 9)	C, A, H, V
Astragalus kentrophyta	prairie (15)	C, A, H, V
Astragalus pectinatus#	prairie (1, 6*)	C, A, H, V
Astragalus striatus	prairie (2, 6, 8)	C, A, H, V
Astragalus vexilliflexus	alpine (12b)	DSF
Glycyrrhiza lepidota	prairie (2, 6, 8)	C, A, H, V
Hedysarum alpinum ssp. *americanum*	prairie (6, 8)	–, A, H, V
Hedysarum sulphurescens	prairie (8)	C, A, H, V
Lathyrus ochroleucus	prairie (2)	C, A, H, V
Lupinus argenteus#	prairie (2, 6, 8)	C, A, H, V
Oxytropis splendens	prairie (6)	C, –, H, V
Oxytropis jordalii ssp. *jordalii*	alpine (12a)	DSF
Oxytropis viscida#	prairie (2, 6, 8)	C, A, H, V
Petalostemon candidum	prairie (9)	–, –, H, V
Petalostemon purpureum#	prairie (2, 6, 8)	C, A, H, V
Thermopsis rhombifolia#	prairie (1, 2, 6*, 8)	C, A, H, V
Vicia americana#	prairie (6, 8)	C, A, H, V
Liliaceae		
Allium cernuum	prairie (2, 6)	C, A, H, V
Allium textile#	prairie (2, 6*, 8)	C, A, H, V
Calochortus apiculatus	montane (11)	DSF
Disporum trachycarpum	boreal forest (13)	–, –, H, V +DSF
Erythronium grandiflorum	montane (11)	–, A, H, V +DSF
Lilium philadelphicum var. *andinum*	parkland (14a)	C, A, H, V
Smilacina racemosa var. *amplexicaulis*	boreal forest (13)	–, –, H, V +DSF
Smilacina stellata	parkland (14a)	C, A, H, V
Streptopus amplexifolius var. *americanus*	boreal forest (20)	C, A, H, V
Tofieldia glutinosa	parkland (19)	C, –, H, –
Tofieldia pusilla	alpine (12a)	DSF
Linaceae		
Linum lewisii#	prairie (6*, 8)	C, A, H, V
Lobeliaceae		
Lobelia kalmii	parkland (16b)	C, A, H, V
Malvaceae		
Sphaeralcea coccinea	prairie (1, 6*, 8)	C, A, H, V
Menyanthaceae		
Menyanthes trifoliata	parkland (14b)	lacking
Nymphaceae		
Nuphar variegatum	parkland (14 pond)	lacking
Onagraceae		
Epilobium angustifolium ssp. *angustifolium*	parkland (14a)	C, A, H, V +DSF
Epilobium latifolium	alpine (12b)	DSF
Gaura coccinea	prairie (6, 8)	C, A, H, V
Oenothera biennis	parkland (14a)	C, A, H, V
Oenothera nuttallii	prairie (2)	C, A, H, V
Orchidaceae		
Calypso bulbosa	montane (18)	ORCH
Corallorhiza maculata	montane (18)	ORCH
Corallorhiza trifida	montane (18)	ORCH
Cypripedium passerinum	parkland (19)	ORCH
Goodyera oblongifolia	montane (11)	ORCH
Goodyera repens var. *repens*	parkland (14a)	ORCH
Habenaria hyperborea	parkland (19)	ORCH

TABLE 1. Occurrence of root-associated fungi in 179 plant species native to Alberta (*continued*).

Taxa	Region (site)	Root-associated fungi[1]
Habenaria viridis var. *bracteata*	alpine (12b)	ORCH
Listera borealis	montane (18)	ORCH
Orchis rotundifolia	parkland (16a)	ORCH
Spiranthes romanzoffiana	parkland (19)	ORCH
Orobanchaceae		
Orobanche fasciculata	montane (11)	lacking
Parnassiaceae		
Parnassia fimbriata	parkland (12a)	DSF
Parnassia palustris	parkland (14a)	C, A, H, V
Polemoniaceae		
Phlox hoodii#	prairie (1, 6, 8)	C, A, H, V
Polemonium acutiflorum	alpine (12a)	DSF
Polygonaceae		
Eriogonum flavum#	prairie (2, 6*, 8)	C, –, H, V
Polygonum amphibium	parkland (14b)	lacking
Polygonum douglasii	montane (11)	lacking
Polygonum viviparum	alpine (12b)	DSF
Polypodiaceae		
Dryopteris carthusiana	parkland (14a)	lacking
Gymnocarpium dryopterus	parkland (14a)	lacking
Primulaceae		
Androsace chamaejasme	alpine (12b)	DSF
Dodecatheon conjugens#	prairie (6)	C, A, H,
Lysimachia thyrsiflora	parkland (14b)	C, A, H, V
Pyrolaceae		
Orthilia secunda	parkland (14a)	–, –, H, –, ARB
Pyrola asarifolia	parkland (14a)	–, A, H, –, ARB
Ranunculaceae		
Aconitum delphinifolium	alpine (12a)	C, A, H, V +DSF
Anemone multifida	prairie (8)	C, A, H, V
Anemone patens#	prairie (2, 6*, 7, 8)	C, A, H, V
Aquilegia flavescens	alpine (12a)	DSF
Caltha palustris ssp. *palustris*	parkland (19)	lacking
Clematis ligusticifolia	prairie (15)	C, A, H, V
Delphinium glaucum	alpine (12a)	C, A, H, V +DSF
Trollius albiflorus	alpine (12a)	DSF
Rosaceae		
Fragaria virginiana ssp. *glauca*	parkland (14a)	– ,–, H, V, +DSF
Geum triflorum#	prairie (6*, 8)	C, A, H, V
Potentilla anserina#	prairie (6)	C, A, H, V
Potentilla concinna#	prairie (6, 8)	C, A, H, V
Potentilla plattensis	prairie (6, 8)	C, A, H, V
Rubus arcticus ssp. *acaulis*	parkland (14b)	–, –, H, V +DSF
Rubus idaeus ssp. *melanolasius*	parkland (14a)	C, A, H, V
Rubus pubescens	parkland (14a)	C, A, H, V +DSF
Sibbaldia procumbens	alpine (12b)	C, A, H, V
Rubiaceae		
Galium boreale#	prairie (2, 6*, 8)	C, A, H, V
Santalaceae		
Comandra umbellata var. *pallida#*	prairie (6*, 8)	C, A, H, V

TABLE 1. Occurrence of root-associated fungi in 179 plant species native to Alberta (*concluded*).

Taxa	Region (site)	Root-associated fungi[1]
Saxifragaceae		
Mitella nuda	parkland (14a)	C, A, H, V
Saxifraga bronchialis	alpine (12b)	DSF
Saxifraga lyalli	alpine (12a)	DSF
Saxifraga oppositifolia	alpine (12b)	DSF
Saxifraga tricuspidata	alpine (12b)	DSF
Scrophulariaceae		
Besseya wyomingensis#	prairie (2, 6*, 8)	C, A, H, V
Orthocarpus luteus	prairie (3, 5)	lacking
Pedicularis bracteosa	alpine (12a)	DSF
Pedicularis capitata	alpine (12a)	DSF
Pedicularis flammea	alpine (12a)	DSF
Pedicularis groenlandicum	parkland (19)	lacking
Pedicularis lanata	alpine (12b)	DSF
Penstemon nitidus#	prairie (2, 6*, 7, 8)	C, A, H, V
Veronica alpina var. *alternifolia*	alpine (12a)	DSF

[1]Abbreviations for root-associated fungi: C = coils, A = arbuscules, H = hyphae, V = vesicles, DSF = dematiaceous surface fungi, ARB = arbutoid mycorrhizal fungi, ORCH = orchidaceous mycorrhizal fungi.
*Species for which at least two populations were sampled, see text.
#Species sampled in June and September, 1983, see text (unmarked species were sampled in July or August, 1981 and 1982).

these groups of root-associated fungi in 179 plant species.

Discussion

With the exception of the Orchidaceae, which are discussed together with montane species, taxa are treated according to the ecoregions from which they were collected. Table 2 summarizes observations on the occurrence of root-associated fungi according to plant family and ecoregion.

Of the five Alberta ecoregions examined, root collections from prairie environments demonstrated the heaviest infections by VAM. In species sampled during June and September, VAM generally appeared to be heavier in the fall collections.

Two of the most researched aspects of VAM are the effects of the symbiosis in improving water uptake and phosphate absorption (Smith 1980). At the short grass prairie sites from which our samples were taken, soils were low in available phosphates even though insoluble calcium phosphates were abundant (Smreciu and Currah 1980; Currah et al. 1981). Moisture is also a significant limiting factor in plant growth at these semi-arid sites. It would be reasonable to expect many of the prairie species to be mycorrhizal, given the highly competitive environment they inhabit (Miller 1979; Rose 1981; Stahl and Christensen 1982). Nearly all of the 85 prairie species examined had VAM but there were some notable exceptions. *Draba oligosperma, Physaria didymocarpa* (Cruciferae), *Atriplex nuttallii* and *Salicornia rubra* (Chenopodiaceae) lacked VAM. The Cruciferae and Chenopodiaceae are both discussed by Hirrell et al. (1978) as having debatable abilities to form VAM symbiosis, and Pirozynski (1980) referred to the Cruciferae (Brassicaceae) as being one of the plant groups "liberated" from endomycorrhizal dependence. Pirozynski also noted a correlation between "weediness," propensity to colonize marginal habitats, annual growth habit, and a decreasing dependence on mycorrhizal fungi. None of *Arabis holboellii, Draba oligosperma*, or *Physaria didymocarpa* is annual but all are found in poor, coarse-textured soils where competition from other species is low. *Atriplex nuttallii* is reported as being non-mycorrhizal (Trappe 1981) but VAM has been observed in the closely related *Atriplex gardneri.* (Allen 1983).

In the Scrophulariaceae, both *Penstemon nitidus* and *Besseya wyomingensis* were very heavily colonized by VAM. The roots of *Orthocarpus luteus*, an annual species, demonstrated a few, broad, aseptate hyphae among the cortical cells of two separate collections. This hemiparasitic species, a close relative of *Castilleja*, forms "sucker-like attachments to the roots of other plants" (Kuijt 1972) and has thereby developed an alternate method for obtaining nutrients. Although it is not a taxon included in this report, we have also failed to find VAM in roots of *Castilleja* species from a variety of habitats. In contrast to these non-mycorrhizal, hemiparasitic Scrophulariaceae, the specimens of

TABLE 2. Summary of the occurrence of root-associated fungi in plant families of prairie, parkland, boreal forest, montane and alpine regions of Alberta.

Family	Prairie	Parkland	Boreal forest	Montane	Alpine
Adoxaceae			(1) lacking		
Alismataceae			(1) lacking		
Apocynaceae		(1) VAM			
Araceae		(1) lacking			
Araliaceae		(1) VAM			
Asclepiadaceae	(1) VAM				
Boraginaceae	(1) lacking		(1) VAM		
Cactaceae	(2) VAM				
Campanulaceae	(1) VAM				(1) DSF
Caprifoliaceae		(1) VAM + DSF			
Caryophyllaceae	(2) VAM				(1) VAM + DSF
Chenopodiaceae	(2) lacking				
Compositae	(30) VAM	(3) VAM		(2) VAM	(3) DSF/(1) VAM + DSF
	(1) lacking				
Cornaceae		(1) VAM + DSF			
Crassulaceae				(1) VAM	
Cruciferae	(3) lacking				(1) lacking
Equisetaceae		(3) lacking			(1) DSF
Ericaceae					(1) DSF
Gentianaceae					(3) DSF
Geraniaceae	(1) VAM				
Gramineae		(1) VAM			
Hydrophyllaceae				(1) lacking	
Iridaceae	(1) VAM				
Labiatae	(1) VAM				
Leguminosae	(18) VAM				(3) DSF
Liliaceae	(2) VAM	(3) VAM	(1) VAM/(2) VAM + DSF	(1) DSF/(1) VAM + DSF	(1) DSF
Linaceae	(1) VAM				
Lobeliaceae		(1) VAM			
Malvaceae	(1) VAM				
Menyanthaceae		(1) lacking			
Nymphaceae		(1) lacking			
Onagraceae	(2) VAM	(1) VAM/(1) VAM + DSF			(1) DSF
Orchidaceae		(5) ORCH		(5) ORCH	(1) ORCH
Orobanchaceae				(1) lacking	
Parnassiaceae		(1) VAM			(1) DSF
Polemoniaceae	(1) VAM				(1) DSF
Polygonaceae	(1) VAM	(1) lacking		(1) lacking	(1) DSF
Polypodiaceae		(2) lacking			
Primulaceae	(1) VAM	(1) VAM			(1) DSF
Pyrolaceae		(1) ARB/(1) VAM + ARB			
Ranunculaceae	(3) VAM	(1) lacking			(2) DSF/(2) VAM + DSF
Rosaceae	(4) VAM	(1) VAM/(3) VAM + DSF			(1) VAM
Rubiaceae	(1) VAM				
Santalaceae	(1) VAM				
Saxifragaceae		(1) VAM			(4) DSF
Scrophulariaceae	(2) VAM	(1) lacking			(5) DSF
	(1) lacking				

Comandra umbellata var. *pallida* (Santalaceae) all demonstrated very heavy VAM associations. Toth and Kuijt (1977) did not report endomycorrhizae in their study of the root parasitic structures of field-collected specimens of this species.

Malloch et al. (1980) noted that "Caryophyllaceae usually lack mycorrhizae" but added that although this was true for "weedy" species, "the woody members will probably be found to be endotrophic . . . when they are examined." This prediction is substantiated here since both *Arenaria congesta* and *Paronychia sessiliflora* were heavily colonized by vesicular arbuscular mycorrhizal fungi. These long-lived, herbaceous species form a persistent woody caudex.

When compared to other families of prairie species examined, the Leguminosae consistently exhibited the heaviest levels of VAM infection. Leguminous species were also heavily nodulated. With the exception of *Antennaria umbrinella*, prairie Compositae were also heavily endomycorrhizal.

Of the 39 species examined from the parkland region, 22 had VAM; some of these also had other types of root-associated fungi, viz. DSF and ARB. Parkland species lacking root-associated fungi are discussed first. *Menyanthes trifoliata* lacked root-associated fungi. Pirozynski (1980) and Malloch et al. (1980) note that aquatic vascular plants and plants of waterlogged soils tend to lack endomycorrhizae. *Menyanthes* is not strictly aquatic and our plants were collected from a *Larix* fen where they were anchored in moss hummocks composed of *Aulacomium palustre, Drepanocladus aduncus, Helodium blandowii*, and *Tomenthypnum nitens*. There are no data on mycorrhizal status of other Menyanthaceae. *Nuphar variegatum*, a strictly aquatic species, also lacked root-associated fungi.

The root samples from the Polypodiaceae, *Dryopteris spinulosa* and *Gymnocarpium dryopteris*, were non-mycorrhizal. These results are in contrast with those of Berch and Kendrick (1982) who observed up to 95% infection in these species in collections from southern Ontario. Malloch and Malloch (1982) also reported a high level of endomycorrhiza formation in *G. dryopteris*. Our negative results might be attributed to small sample size. The three parkland *Equisetum* species all lacked root-associated fungi. Extant species of this genus are noted for their lack of endomycorrhizae. Fossil specimens of carboniferous Equisetales apparently demonstrate that endomycorrhizae were once common in arborescent members of this group (Malloch et al. 1980).

Lobelia kalmii and *Pedicularis groenlandicum* were collected from the margin of a marl pond. *Lobelia kalmii* was heavily colonized by VAM whereas *Pedicularis groenlandicum* displayed no sign of root-associated fungi. Phosphate uptake in calcareous marls might be enhanced by a VAM association. *P. groenlandicum*, another parasitic Scrophulariaceae, might obtain sufficient nutrients by parasitizing neighbouring species (in this case, *Carex* spp.) and therefore might not require a mycorrhizal associate.

Pyrola asarifolia and *Orthilia secunda* both demonstrated arbutoid mycorrhizae. *P. asarifolia* also displayed some evidence of VAM. Malloch and Malloch (1982) and Robertson and Robertson (1985) have also reported on the occurrence of arbutoid mycorrhiza in these species. In contrast, Largent et al. (1980) failed to find root-associated fungi of any type in *Orthilia secunda* from California.

Our observations on the occurrence of VAM in parkland collections of *Cornus canadensis* and *Aralia nudicaulis* are in agreement with those of Malloch and

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FIGURES 2-7. Hyphal configurations used in distiguishing among four main types of root-associated fungi.

2. Root tip of *Astragalus striatus* (Elkwater) showing darkly staining vesicles ("V" arrows) within the cortex. X150.

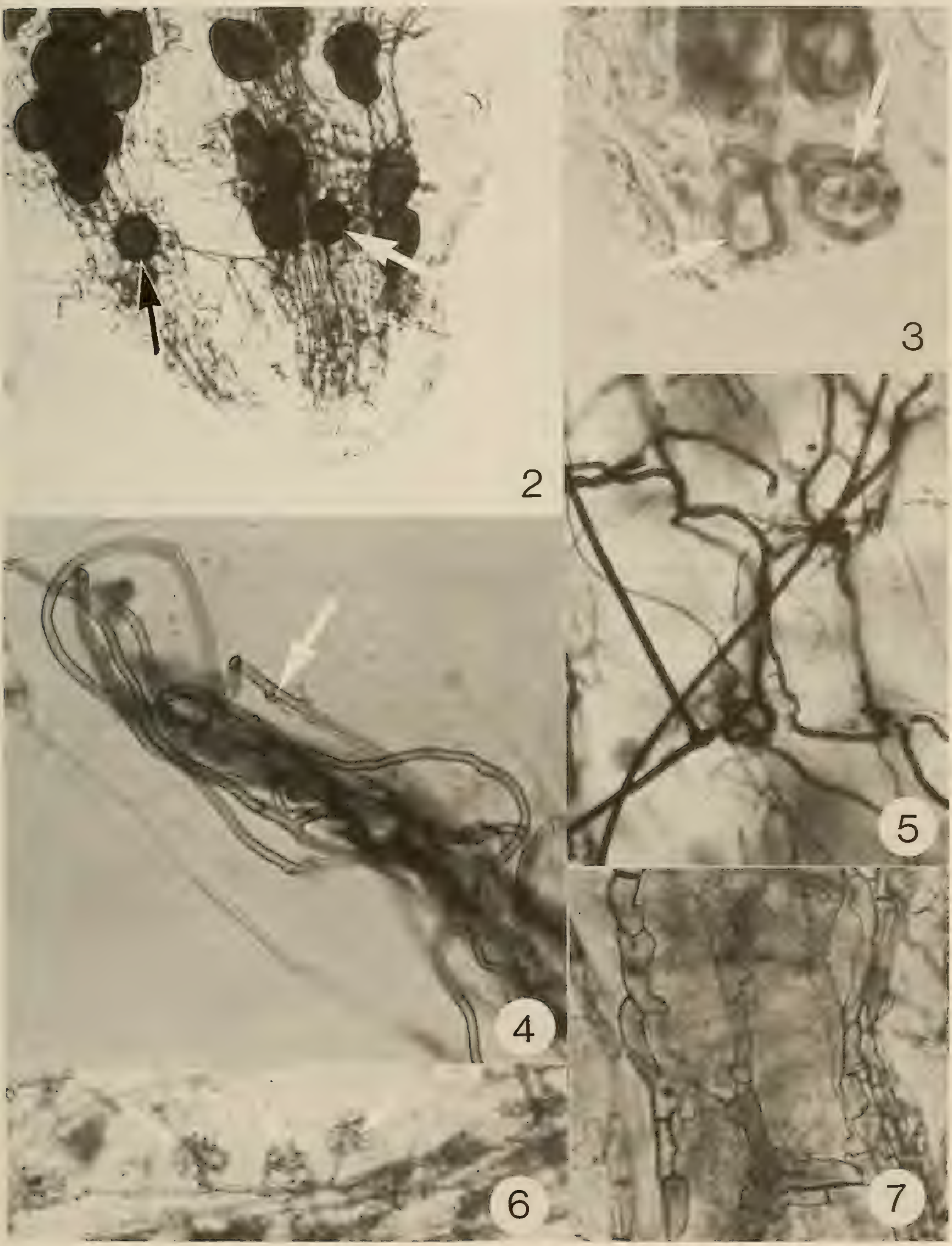
3. Cortical cells of *Comandra umbellata* var. *pallida* (Milk River Ridge) with large coils ("C" arrows) of broad hyphae. X350.

4. Cortical cell of coralloid rhizome of *Corallorhiza trifida* (Devonian Botanic Garden) containing a tangled mass of slender, thin-walled hyphae. Arrow indicates clamp connection. X400.

5. Root surface of *Calochortus apiculatus* (Cardinal River Divide) with investiture of dematiaceous hyphae. X370.

6. Root cortex of *Vicia americana* (Milk River Ridge) showing arbuscules ("A" arrows) within cortical cells. X250.

7. Root of *Orthilia secunda* (Devonian Botanic Garden) exhibiting characteristic arbutoid mycorrhizal hyphae on surface. X440.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Malloch (1981) for boreal forest collections of these species.

The roots of only five species from the boreal forest were examined for mycorrhizae. *Adoxa moschatellina* (Adoxaceae) lacked root-associated fungi, as did the aquatic *Sagittaria cuneata*. Malloch and Malloch observed endomycorrhizae in *Linnaea borealis* var. *longiflora* (1981) and in *Streptopus roseus* (1982). Our similar observations with *Linnaea borealis* ssp. *americana* and *Streptopus amplexifolius* var. *americanus* are in agreement for these closely related taxa.

A large proportion of vascular plants studied from the montane sites were orchids. With the exception of *Listera borealis*, all collections, including those from the parkland ecoregion, displayed extensive infections by a similar (if not identical) type of mycorrhizal fungus. Morphology of the hyphae and hyphal configurations within the cells from species to species were apparently consistent. Although the presence and identity of mycorrhizal fungi have been investigated in some detail in Australian orchids (Warcup 1981), the mycorrhizae of North American terrestrial orchids have not been studied. Surprisingly, Malloch et al. (1980) state that mature, autotrophic orchids "appear to be non-mycorrhizal," but no documentation is offered as support for this statement. *Corallorhiza trifida*, a heterotrophic orchid, demonstrated extensive infection by a fungus within the cortical cells of the rhizome while *Spiranthes romanzoffiana*, an autotrophic species, demonstrated a similar type and extent of infection. With the exception of *Listera borealis*, which has been noted by other authors (Furman and Trappe 1971) to have minimal mycorrhizal involvement, there appeared to be few qualitative differences between infection in the autotrophic and heterotrophic species. Presumably decreased chlorophyll would correspond to increased dependence on a mycobiont (Furman and Trappe 1971). A quantitative comparison between the mycorrhizal components of heterotrophic and autotrophic orchid species might demonstrate such a correspondence.

The only montane species lacking root-associated fungi was *Polygonum douglasii*. The Polygonaceae, although referred to by Pirozynski (1980) as another of the plant groups liberated from a dependence on mycorrhizal fungi, does form endomycorrhizal associations in the perennial species we examined from the prairie region, i.e. *Eriogonum flavum*.

There was a distinct correlation between habitat and the type of root-associated fungi in collections from alpine regions. Our observations of root-associated fungi of 36 herbaceous plant species from alpine environments agree with those of Berch and Kendrick (1982) and Miller (1982) who found that plants in habitats lacking organic matter also lacked VAM. We observed that species collected in alpine soils with little organic matter had DSF, whereas species growing in habitats with visibly more organic matter (e.g. *Arnica cordifolia* and *Aconitum delphinifolium*) had VAM. Notably, the three alpine species of Leguminosae examined here (*Astragalus alpinus*, *Astragalus vexilliflexus*, and *Oxytropis jordalii*) all lacked VAM – a significant observation in a family that is strongly endomycorrhizal in other habitats.

Smelowskia calycina var. *americana* (Cruciferae) was the only species lacking root-associated fungi. One of the four alpine species demonstrating both VAM and DSF, *Silene acaulis*, was also noted by Haselwandter and Read (1980) as having both of these types of fungi in collections made in the Austrian Alps. Subsequent studies by these authors found that infection by dark septate hyphae was common in healthy plants of alpine areas (Read and Haselwandter 1981). Isolation of two strains of these dematiaceous fungi and reinoculation on to aseptically grown plants of *Carex firma* (Haselwandter and Read 1982) caused a significant increase in dry matter production. This would indicate that the association offers some competitive advantage for the host plant in its natural environment.

Although several studies have examined the identity and distribution of fungi in alpine soils (Bissett and Parkinson 1979a,b,c), there are apparently no accounts of the isolation or identification of these dematiaceous, root-associated fungi from alpine zones of North America. Isolation and identification of these organisms would be a first step in determining the ecological significance of the association.

During this survey it was not possible to sample more than once many of the species reported here. Therefore a negative report concerning root-associated fungi cannot be regarded as conclusive. Clearly, from the widespread distribution of root-associated fungi, a significant ecological benefit is being derived by the plant species involved in the association. Further studies of the autecology and synecology of native flora should consider mycorrhizal relationships in some detail.

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Choice of Nest Boxes by Tree Swallows, *Tachycineta bicolor*, House Wrens, *Troglodytes aedon*, Eastern Bluebirds, *Sialia sialis*, and European Starlings, *Sturnus vulgaris*

HARRY G. LUMSDEN

Ontario Ministry of Natural Resources, Wildlife Research Section, P.O. Box 50, Maple, Ontario L0J 1E0

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Controlled experiments with nest boxes mounted in sets of two or three in which one feature was varied were done from 1975 to 1983. Tree Swallows preferred boxes facing south, a floor plan of 15.3 × 15.3 cm to one 10 × 10 cm, and a depth from the bottom of the entrances to the floor of 12 cm to 16.5 cm. House Wrens preferred entrances 3.2 cm in diameter to ones 2.2 and 2.5 cm, but readily used holes 3.5 and 4.4 cm. They preferred a floor plan 10 × 10 cm to one 15.3 × 15.3 cm. They rejected white but accepted black interiors in long low boxes, but accepted both black and white interiors in upright boxes which admitted less light. Eastern Bluebirds preferred entrances 4.4 cm in diameter to those 3.5 cm. Three times as many Eastern Bluebirds used boxes with a floor plan 10 × 10 cm as used those with a floor plan 15.3 × 15.3 cm. European Starlings (*Sturnus vulgaris*) preferred goldeneye boxes 33 cm deep to those 24 and 18 cm. Competition among species might be reduced by using features preferred by one and disliked by others.

Key Words: Tree Swallow, *Tachycineta bicolor*, House Wren, *Troglodytes aedon*, Eastern Bluebird, *Sialia sialis*, European Starling, *Sturnus vulgaris*, nest box, preferences, competition.

The literature on building nest boxes for passerine birds is very extensive but consolidated accounts are available (Cayouette 1978; Henderson 1984; Kibler 1969; Kalmbach and McAtee 1969; and others). There have been a number of studies testing the preferences of secondary cavity-nesters for various nest-box properties in Europe (Lohrl 1970; Hublé 1964; Henze 1964; Nilsson 1975; Van Balen 1972, 1982) and in New Zealand (Coleman 1974; Moeed and Dawson 1979), but few controlled experiments have been carried out in North America. Although most of the recommended designs work, in that birds will use them readily, few controlled experiments have been done to find out which features each species prefers. Design changes could improve acceptance of boxes and might even reduce competition among species.

From 1975 to 1983 I did controlled experiments to find out which nest-box features were favoured by Tree Swallows (*Tachycineta bicolor*), House Wrens (*Troglodytes aedon*), Eastern Bluebirds (*Sialia sialis*), and European Starlings (*Sturnus vulgaris*).

Materials and Methods

Choices were evaluated in sets of boxes mounted together, in which one feature varied within the set. Within a set, the boxes were spaced 1 m apart or were mounted with entrances 30 cm apart side by side, or back to back on the same post, or on trees for European Starlings. Sets were spaced 45 m apart in parallel rows which were, in turn, 50 m apart.

The main study was at Anten Mills, Ontario (44°29′N, 79°50′W). There, abandoned fields were planted in 1972-1983 to Karelian Birch (*Betula verrucosa*), Paper Birch (*Betula papyrifera*), European Alder (*Alnus glutinosa*), Trembling Aspen (*Populus tremuloides*), Large-toothed Aspen (*Populus grandidentata*), hybrid poplars, and hybrid filhazels. By 1983 some trees were up to 8 m tall but most were 2–4 m tall. Rows of boxes were placed in the plantation, at its edge, in the open, or in a relatively open natural young stand composed of willow (*Salix* sp.), Paper Birch, Trembling Aspen, White Cedar (*Thuja occidentalis*) and Tamarack (*Larix laricina*). Boxes were also put up at Aurora, Ontario (44°00′N, 79°28′W) spaced 50 m+ apart in a garden with trees, shrubs, mowed and long grass areas, and ponds. A third study area was at Long Lake near Charlton (47°48′N, 79°50′W) in east-central Ontario where European Starlings used goldeneye boxes. For details on that study area see Lumsden (1976) and Lumsden et al. (1980).

Boxes were made from 1 cm or 1.3 cm sheeting grade plywood coloured on the outside with brown or grey-green stain. The measurements given below are all interior dimensions. They were mounted on posts about 1.5 m above the ground, but boxes used by European Starlings were placed 3 m above the ground. Use of a box by Tree Swallows, Eastern Bluebirds, or European Starlings was defined as building a nest and laying one or more eggs, whether or not the clutch was completed.

Male House Wrens select a cavity and build a nest. Females line and lay in some of those nests. A House Wren was scored as having used a box when it built a

TABLE 1. Choice of boxes with black or white interiors by Tree Swallows, House Wrens, and Eastern Bluebirds.

Species	Boxes	Black	White
Tree Swallow	Upright and long low boxes*	23	22
House Wren	Upright boxes	20	16
	Long low boxes	10	0
Eastern Bluebird	Upright boxes	3	1

*No significant difference ($P > 0.05$) in choice between black and white in either of the two kinds of boxes. They have been combined here. House Wren, long low boxes: Binomial Tables $P < 0.001$.

complete nest whether or not that was subsequently used by a female. Boxes with a few twigs or an incomplete nest were not considered as a choice.

Test 1: In 1978-79 the inside of one box of a pair was painted black and the other painted white. I used two box designs. A conventional upright box with a 12 × 10 cm floor plan 16.5 cm deep at the front and 17 cm deep at the back was mounted for Tree Swallows. Forty and 55 sets of boxes in 1978 and 1979 were available, respectively. For House Wrens I used a long low box with a 18.5 × 10.5 cm floor plan 8.5 cm deep. Twenty-five pairs of boxes were available each year. Entrances were all 3.5 cm in diameter and all boxes faced west.

Test 2: Various studies have shown that cavity entrances are not randomly oriented as far as points of the compass are concerned (McLaren 1963; Conner 1975). To test selection I mounted two boxes back to back on the same post, one facing north and the other south. Eighty-five sets of boxes were available in 1980 and 10 in 1981. The boxes used in 1978-79 were used again, but were paired so that boxes of similar design and colour were placed together.

Test 3: Recommended entrances for nest boxes vary greatly. I tested the preference of House Wrens for entrances 2.2 cm and 2.5 cm vs. 3.2 cm in 1981 and 1982, respectively, and also 3.5 cm vs. 4.4 cm in 1982 with 30 sets of long low boxes. For Tree Swallows and Eastern Bluebirds I tested 3.5 cm vs. 4.4 cm entrances with 72 sets of upright boxes in 1981 and 20 sets in 1982.

Test 4: Recommended internal measurements of boxes vary greatly. In 1981-83, I used boxes 15.3 × 15.3 cm with a depth of 17.7 cm at the front and 21.5 cm at the back. The bottom of the entrance was 12 cm from the floor. The volume was 4588 cm^3. Into half of these boxes I built inserts which restricted the floor plan to 10 × 10 cm and reduced the volume available for the nest to 1935 cm^3. Twenty sets in 1981, 10 in 1982, and 23 in 1983 were mounted.

Test 5: In 1982-83, I used boxes similar to those in Test 4 with variation in the level of the floor in half of the boxes so that in the deep ones the bottom of the entrance was 16.5 cm from the floor, and in the shallow it was 12 cm. Twenty pairs of boxes were available each year.

Test 6: European Starling preference for shallow (18 cm from the bottom of the entrance to the floor), medium (24.5 cm) and deep (33 cm) boxes put up for Common Goldeneyes, *Bucephala clangula*, was measured at Long Lake. In 1977, 105 and in 1978, 103 sets of 3 boxes were available.

Results

In Test 1 in a choice between black or white box interiors, the Tree Swallows were indifferent ($P > 0.05$, Table 1). The House Wrens' choice pattern was more complicated and the results from the two types of boxes used differed ($P < 0.001$). In the conventional upright boxes there was no significant choice, but in the long low boxes the wrens preferred those with black interiors ($P < 0.001$, Table 1).

In Test 2 where the boxes faced north or south, Tree Swallows preferred those facing south ($P < 0.02$, Table 2), but the House Wrens made no choice. Results for the different box designs and interior colours did not differ and were therefore combined. All but 8 of the 95 sets available were used.

Test 3 showed that House Wrens far preferred entrances 3.2 cm in diameter to those 2.2 and 2.5 cm ($P < 0.001$, Table 3). House Wrens and Tree

TABLE 2. Choice of boxes facing north and south by Tree Swallows, House Wrens, and Eastern Bluebirds.

Species	North-facing	South-facing
Tree Swallow	20	39
House Wren	10	10
Eastern Bluebird	2	1

Tree Swallow $\chi^2 = 6.17$, 1 df, $P < 0.02$.

TABLE 3. Choice of boxes with varying sizes of entrance holes among House Wrens, Tree Swallows, and Eastern Bluebirds.

Species		Entrance diameter 2.2 cm	2.5 cm	3.2 cm	3.5 cm	4.4 cm
House Wren	1981	0	–	13	–	–
	1982	–	0	13	–	–
	1981-2	–	–	–	11	6
Tree Swallow	1981-2	–	–	–	24	23
Eastern Bluebird	1981-2	–	–	–	0	7

House Wren 1981: Binomial Tables $P < 0.001$
House Wren 1982: Binomial Tables $P < 0.001$
Eastern Bluebird 1981-2: Binomial Tables $P < 0.01$

Swallows showed no significnt choice between entrances 3.5 and 4.4 cm; however, Eastern Bluebirds preferred the larger entrance ($P < 0.01$, Table 3).

Test 4 of boxes with a floor plan of 15.3 × 15.3 cm and a volume of 4588 cm^3 vs. boxes with a floor plan of 10 × 10 cm and a volume of 1935 cm^3 showed that Tree Swallows preferred the larger size ($P < 0.001$, Table 4), but House Wrens preferred the smaller ($P < 0.002$). Although the result is not significant, three times as many Eastern Bluebirds chose the smaller volume as the larger.

Test 5, in which boxes with the bottom of the entrances 12 cm from the floor were tested against deeper boxes with a measurement of 16.5 cm between entrance and floor, showed that Tree Swallows preferred the shallower ($P < 0.05$).

Test 6 revealed the strong preference ($P < 0.001$) of European Starlings for deep (33 cm) boxes over those measuring 24.5 cm or 18 cm from the bottom of the entrance hole to the floor (Table 6).

TABLE 4. Choice of boxes with floor plan 15.3 × 15.3 cm (volume 4588 cm^3) vs. 10 × 10 cm (volume 1935 cm^3) by Tree Swallows, House Wrens, and Eastern Bluebirds.

Species	Floor plan 15.3 × 15.3 cm	10 × 10 cm
Tree Swallow	22	6
House Wren	8	45
Eastern Bluebird	3	9

Tree Swallow $\chi^2 = 9.14$, 1df, $P < 0.001$
House Wren $\chi^2 = 25.83$, 1df, $P < 0.001$

TABLE 5. Choice between shallow depth (12 cm) entrance to floor and deep (16.5 cm) boxes by Tree Swallows and House Wrens.

Species	Shallow	Deep
Tree Swallow	21	9
House Wren	2	2

Tree Swallow $\chi^2 = 4.8$, 1df, $P < 0.05$

TABLE 6. Choice of shallow, medium or deep boxes by European Starlings.

Species	Shallow 18 cm	Medium 24.5 cm	Deep 33 cm
European Starling	0	0	11

European Starling: Binomial Tables $P < 0.001$

Discussion

Much of the interest in putting up bluebird boxes stems from the decline of this species due to a shortage of nest cavities (Wallace 1959; Zeleny 1978) and competition from other secondary cavity-nesters (McLaren 1963; Pinkowski 1974; Erskine and McLaren 1976; Willner et al. 1983). This study of preferences for certain nest box features by four cavity-nesting species suggests that certain combinations of features might be used to reduce competition.

Interior Colour

The colour of the interior of a box affects the reflection of light admitted by the entrance. The amount of reflected light at the bottom of a box will also depend on its depth. Preferences for the amount of light within a box probably vary among species. Blagosklonov (1970), in uncontrolled experiments, concluded that the Pied Flycatcher (*Muscicapa hypoleuca*) in the Moscow region used boxes with white or clean interiors more frequently than those with black or dirty interiors. However, European Starlings (Lumsden 1976) and Common Goldeneyes (Lumsden et al. 1980) had a strong preference for black interiors. In the present study only four pairs of Eastern Bluebirds used the boxes with black or white

interiors. However, Pitts (1977) carried out a similar controlled experiment in which Eastern Bluebirds preferred white interiors ($P < 0.05$).

Tree Swallows have occasionally used goldeneye boxes with large entrances which admit more light than the boxes used in this experiment. Their indifference to the interior colour of the boxes in Test 1 suggests a very wide range of light tolerance.

House Wrens made no clear choice between colours in the upright boxes but clearly preferred the black interiors in long low boxes. This choice pattern may have been due to the amount of light entering the box. Light levels were measured at the bottom of the back of the box with a Gossen Microsix L exposure meter. A slot was cut at the back of the box adjacent to the floor to accommodate the sensor. Standard lighting conditions were provided in the laboratory with a 300 W bulb suspended 29 cm above and 18 cm in front of the entrance hole. At f4, long boxes with black and white interiors gave readings of 8.6 and 11.3, respectively, whereas the corresponding figures for tall boxes were 7.2 and 10.6. It seems likely then that the light level within long boxes painted white inside was too high for House Wrens and they were therefore unused. The other boxes were within the range of acceptability.

Box Orientation

Pinkowski (1976) found that significantly more bluebird cavities opened toward the southeast (135° N to 150° N) than any other direction. Bluebirds mostly used woodpecker cavities which also tended to face the southeast. He attributed this to protection from prevailing winds and benefits from the heating effects of the morning sun. Van Balen et al. (1982) in the Netherlands found that European Starlings avoided cavities facing W-NNW, and Verheijen (1969) showed that they preferred those facing E-SE.

In this study Tree Swallows at Anten Mills preferred boxes which faced south to those facing north. It seems likely that some weather factors influenced this choice. The first eggs appear in most nests between 18 May and 1 June. Weather records for May and June were examined for the nearest station at Muskoka, 68 km NW of Anten Mills. Prevailing winds were from the west in May and June (Anonymous 1982) and thus were not likely to have influenced choice between north- and south-facing boxes. I examined the possibility that the birds chose boxes facing away from the prevailing rain winds. The Atmospheric Environment Service (Department of the Environment) provided summaries of the direction and number of hours of winds 17.7 – 56 km/h (11–35 mph) when rain was falling for the period 1957-1976 for Muskoka: in May 53% and in June 48% of rain winds were from the east to south quarter. Tree Swallows therefore did not choose boxes facing away from the prevailing rain winds which could be expected to wet nests.

I next examined wind chill for its possible influence on box selection. The Atmospheric Environment Service provided summaries of the number of hours in May and June 1957-1980 of wind chill recorded by wind direction. For a wind chill range from 0 to 1400 watts/m^2, 32% of the hourly recorded winds occurred in the SE-SW quarter, but only 25% from NW-NE. The highest proportion of chill units came on winds blowing from SW to NW (43%). Wind chill units in the low range are not likely to have much influence on Tree Swallows. We do not know the wind chill level at which Tree Swallows are stressed. *Homo* starts to feel discomfort when the chill factor exceeds 1100 watts/m^2. Figure 1 summarizes the wind direction for wind chill > 1100 watts/m^2 for Muskoka.

In the NW-NE quarter, the proportion of chill units was 68%, but in the SE-SW quarter only 4%. It therefore seems possible that Tree Swallows were influenced by wind chill in their choice of box orientation and faced away from the quarter from which the highest frequency of chill units above 1100 watts/m^2 came.

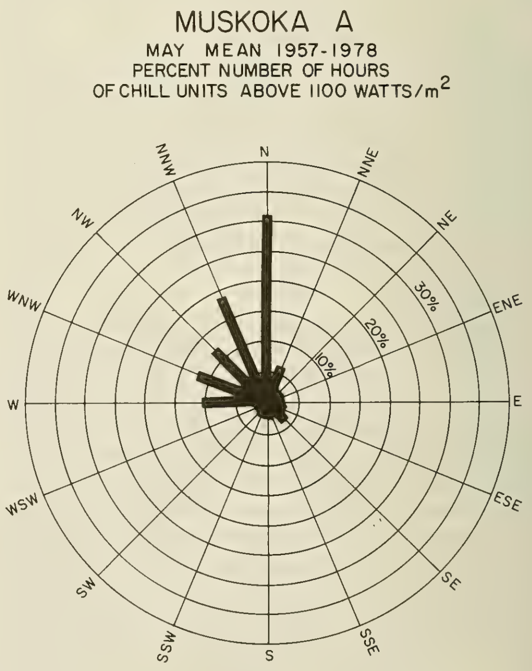

FIGURE 1. Wind direction when the chill units exceeded 1100 watts/m^2.

Entrance Hole Size

The most commonly recommended size of entrance for Tree Swallow boxes is 3.8 cm in diameter (Kalmbach and McAtee 1969; McNeil 1979; Cayouette 1978; and others). Their lack of discrimination between entrances of 3.5 and 4.4 cm in this study and their use of Wood Duck and goldeneye nest-boxes with entrances 10.5 × 8 cm suggest that entrance size is not critical for this species.

Nest-box entrances for House Wrens have been variously recommended from 2.2 cm (Kendall 1951) to 2.5–3.8 cm (Burtt 1979). Their preferences in this study suggest that 2.2 and 2.5 cm are too small and that 3.2 to 4.4 cm give a more acceptable range. Their preferences for the larger sizes may be influenced by the difficulty they probably experience in carrying relatively large twigs for nest material through a small entrance.

Eastern Bluebirds use a wide range of entrance sizes in natural cavities. Pinkowski (1976) found that in Michigan the mean entrance diameter of natural cavities used at his Stony Creek study area was 4.6 ± 1.0 cm (N=30) where competing European Starlings were present. In the Huron National Forest where there were no starlings, the mean entrance diameter was 6.9 ± 2.0 cm (N=61). The range of sizes was 3.7–13.3 cm. Conner and Adkisson (1974) recorded that Eastern Bluebirds chose entrances 4–12 cm (N=7) in diameter in forest clearings in the Jefferson National Forest, Virginia, where European Starlings were absent.

European Starlings need entrances at least 4.1 cm in diameter (Zeleny 1969) and often choose holes considerably larger than this. McLaren (1963) reported that the smallest entrance chosen by a European Starling in his Cariboo region study area in British Columbia was 4.5 × 5.5 cm. Most starlings there used holes 6 × 6 cm up to at least 9 × 7.5 cm. In the Netherlands, where many species compete for cavities, Van Balen et al. (1982) found that Starlings avoided cavities where entrance holes were larger than 5.5 cm ($P < 0.01$)(N=93). They occupied 65% of the available cavities in the 3.5–4.4 cm class. This suggests that nearly all those larger than 4.1 cm in this size class must have been used. The mean entrance diameter was 4.7 ± 0.7 (N=93). Edington and Edington (1972) reported that in a woodland in Wales where there was a surplus of cavities, the smallest hole used by a European Starling was 6 × 4.5 cm, while they used entrances up to 14 × 19 cm. Zeleny (1978) recommended that to avoid European Starling competition, entrance holes in boxes for bluebirds should not be more than 4.0 cm and not less than 3.6 cm in diameter. Kibler (1969) reviewed the literature on bluebird boxes and found that most box builders use an entrance 3.8 cm in diameter.

At Anten Mills, European Starlings are abundant and breed in kestrel boxes, but none tried to use the nest boxes with 4.4 cm diameter entrances, all of which had white interiors, which may have discouraged them. Thus, Eastern Bluebirds, which overwhelmingly ($P < 0.01$) choose entrances 4.4 cm over those 3.5 cm in diameter, were free of competition from that source.

Internal Measurements

The interior diameter of natural cavities used by Eastern Bluebirds in Michigan was 7.6 ± 0.5 cm (N=21) at Stony Creek where European Starlings were present. Unused cavities at Stony Creek were significantly larger ($\bar{x}$ = 9.0 cm). At the Huron National Forest where European Starlings were absent, the internal diameter of cavities was 9.9 ± 2.5 cm (N=43). The overall range of cavity diameters used was 5.7 – 15.9 cm (Pinkowski 1976).

McLaren (1963) found that European Starlings occupied a broad range of cavities from less than 10 cm to more than 26 cm in diameter, but 58% were in the size range of 10 to 16 cm. Van Balen et al. (1982) reported that the occupation rate (16%) by European Starlings of cavities less than 10 cm in diameter was significantly lower than in larger size-classes in which mean occupancy was 66% of those available. The overall mean diameter was 16.9 ± 4.4 cm (N=92).

Although European Starlings and Eastern Bluebirds accept a wide range of internal diameters for their cavities, it is clear that bluebirds prefer smaller natural cavities. Although the difference was not significant, bluebirds at Anten Mills chose three times as many of the small boxes (10 × 10 cm) as the large (15.3 × 15.3 cm).

Colbert and Berthet (1983) found that European Starlings used fewer nest boxes with reduced internal dimensions of 10 × 10 cm (74%) than standard 15 × 15 cm (90%) boxes. The smaller boxes were mostly used by yearlings and the turnover of pairs was higher than in the larger. This suggests that the smaller boxes provided sites of lower quality for the starlings.

For Tree Swallows and Eastern Bluebirds the internal dimensions are probably important, but for House Wrens, who usually fill a cavity of any size with twigs, the volume may be important. In Test 4 they chose a volume of 1935 cm^3 over five times as often as 4588 cm^3. Tree Swallows differed significantly from Eastern Bluebirds (X^2 = 8.9, df1, $P < 0.01$) and from House Wrens (X^2 = 23.17, df1, $P < 0.001$) in their acceptance of large boxes (15.3 × 15.3 cm) over small (10 × 10 cm). They may need room to use their wings to reach the entrance, as their feet and legs are poorly adapted for hopping.

Depth

The depth from the bottom of the entrance hole to the floor of the box is probably more important than the overall internal height of the box. Tree Swallows frequently use Wood Duck and goldeneye boxes with an entrance to floor measurement of 33 cm. It was desirable to test their preference for boxes deeper than the 12 cm dimension used in Test 4.

The results of Test 5 suggest that the 12 cm depth was favoured by Tree Swallows; however, as nearly 30% of the pairs used boxes with the 16.5 cm depth, the best depth may be somewhere between. No Eastern Bluebirds and too few House Wrens used these boxes to establish a pattern.

European Starlings used goldeneye boxes at Long Lake in 1975 and 1976. These large boxes painted black inside were fitted with entrance holes 13 × 10 cm. These large entrances admitted much light and may have caused the starlings to ignore the boxes with depths of 18 and 24.5 cm. Van Balen et al. (1982), however, found that depth was unrelated to occupation rates and that some starlings used cavities where the bottom was at the same level as the entrance.

Height Above Ground

Variation in the height of natural cavities is great and depends on age, species composition of the forest, and density of trees. Hence we can expect that the mean height of cavities chosen by a species will vary from place to place. In particular, the height of European Starling entrances above ground is variable. Stauffer and Best (1982) in Iowa reported a mean of 9.7 ± 4.5 m (N=22), and Edington and Edington (1972) recorded a mean of 3.48 ± 1.75 m (N=4). Troetchler (1976) in California gave a mean of 8 m and a range of 1.5 – 18 m (N=14).

Van Balen et al. (1982) concluded that the rate of occupancy of cavities for European Starlings did not differ significantly among height classes; however, only 17% of those available in the 0–2 m class were used, suggesting that low sites were avoided by the birds in the Netherlands. The mean height in their study areas was 3.9 ± 1.6 m (N=94). McLaren (1963), however, found that 55% of European Starling nests (N=170) in British Columbia were in the 0–2 m class above ground and were mostly between 1 and 2 m.

The mean height of bluebird entrances tends to be lower than that of starlings, but there is a broad overlap in the ranges. Pinkowski (1976) found that only 27% of Eastern Bluebird nests in Michigan were in the 0–2 m range. He gave a mean height of 3.6 ± 2.9 m with a range of 0.5–16.8 m. Conner and Adkisson (1974) reported a mean of 3.3–1.0 m (N=7) for Eastern Bluebirds in Virginia.

Reduction of competition between European Starlings and Eastern Bluebirds by means of height preferences might be difficult. The frequent use by starlings of farm mail boxes suggests that they will readily accept low sites, particularly when choice is limited in open farmland. However, by combining low elevation with other features that starlings dislike, it may be possible to provide nest boxes that reduce competition. Features favoured by Eastern Bluebirds but avoided by European Starlings include white interiors and small internal dimensions. If a large entrance hole (e.g. 4.4 cm) is provided which is sufficient to admit a starling, it will also admit so much light that starlings can be expected to reject it.

Further tests are needed to find out if Tree Swallow – Eastern Bluebird competition can be reduced with boxes with a floor plan of 15.3 × 15.3 cm vs. 10 × 10 cm.

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Homing by Radio-collared Black Bears, *Ursus americanus*, in Minnesota

LYNN L. ROGERS

USDA–Forest Service, North Central Forest Experiment Station, 1922 Folwell Avenue, St. Paul, Minnesota 55108

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Five Black Bears (*Ursus americanus*) that had been radio-tracked most or all of their lives were transported up to 61 km outside their familiar areas. The three oldest bears quickly moved home or homeward despite their unfamiliar surroundings and despite winds blowing from other than the homeward direction. The prompt returns of these bears support conclusions from previous studies using bears whose familiar areas were unknown: Black Bears can orient homeward without using familiar landmarks.

Key Words: Black Bear, *Ursus americanus*, orientation, navigation, familiar area, movements, nuisance bears, translocation, orphaned cubs, rate of travel, Minnesota.

Black Bears, *Ursus americanus*, commonly return home after being translocated long distances (Erickson et al. 1964; Harger 1970; Alt 1977). However, no bear has previously been monitored before translocation to determine the extent of its familiar area, so that questions have remained as to whether bears that return home demonstrate true navigational ability or simply memory of seldom-used areas (Beeman and Pelton 1976; Baker 1978). This paper presents results of translocation experiments using five Black Bears that were intensively radio-tracked before translocation. Three of them (numbers 436, 462, and 503) were radio-tracked since they were cubs. The other two (littermates 308 and 310) were captured initially as cubs and were recaptured as two- or three-year-olds (see below) in their mother's territory and radio-tracked for a year before translocation. All five were fairly sedentary throughout the radio-tracking period prior to translocation, thereby permitting unusually complete documentation of familiar areas: 562 of 564 attempts to locate them by radio were successful. Radio-locations were obtained primarily by aircraft tracking and were representative of all seasons in each year.

When captured for translocation, each bear was drugged with phencyclidine and promazine and remained unconscious for some or all of the transportation period. Wind directions were recorded at the time of release and determined for subsequent days from U. S. Weather Bureau records. The study was conducted in northeastern Minnesota where terrain is gently rolling, forest habitat is nearly continuous, and there are few large highways, large waterways, or other physiographic features to prevent homing or to channel bears homeward. Towns are widely scattered, and there were no industries or large airports near the bears' home areas to provide cues for homing.

Case Histories

1. Female 436 was radio-tracked during 7.5 years of life, first as a cub by her mother's signals and after 14 months of age by her own radio-collar. She was located 256 times in 257 attempts. Two hundred thirty-eight (93%) of those locations were in an area 9.6 km in diameter, which included her own and her mother's territories. Twelve locations (5%) were obtained outside that area when she accompanied her mother 32 km east as a cub, and six locations (2%) were obtained up to 6 km outside the first area when she was older.

On 16 July 1978, she was drugged and transported unconscious 68 km to a point 60 km northwest of any previous radio-location (Figure 1). From the release point, the homeward direction was a sector 15 degrees wide, covering only 4% (15°/360°) of the directions she could have traveled. She returned to the capture site in nine days, averaging at least 7.5 km/day. Winds were from the home direction the first two days, from behind her the next five days, and from her right the last two days.

2. Female 310 was originally captured as a cub with her mother and was recaptured and radio-collared as a three-year-old at the edge of her mother's territory on 31 May 1972. From then until she was transported in August of the next year, she was located on all 103 telemetry attempts. This period included some extraterritorial wandering as a three-year-old and in her travels as a four-year-old with her first litter. In addition, her mother was radio-tracked in 1970 and 1972 (43 of 43 telemetry attempts successful) to

determine areas where the mother might have led Female 310 as a cub. Mothers commonly use the same feeding areas year after year (Rogers 1977). All locations for 310 and her mother were within an area 11 km across.

Female 310 was captured on 14 August 1973 at a campground that she and her cubs frequented. She was drugged and transported 65 km (Figure 1), without her cubs, to a point 61 km northeast of any previous radio-location. From the release point, the homeward sector (10 degrees wide) covered only 3% (10°/360°) of the directions she could have traveled. Upon release at 1745 h, still partially drugged, she moved farther from home. An hour later she turned around and started directly toward her home range. There was a crosswind from her right. At 1330 h on 17 August, 3.8 days later, she was still on a direct course toward home and 43 km closer to it, having averaged 11.4 km/day. Winds during this period had changed from the crosswind to a tailwind. Contact then was lost. She was assumed to have been poached at the point of signal loss because she was not found during an extensive aerial telemetry search and was not recovered during subsequent years of live-trapping in her home area or during statewide hunting seasons.

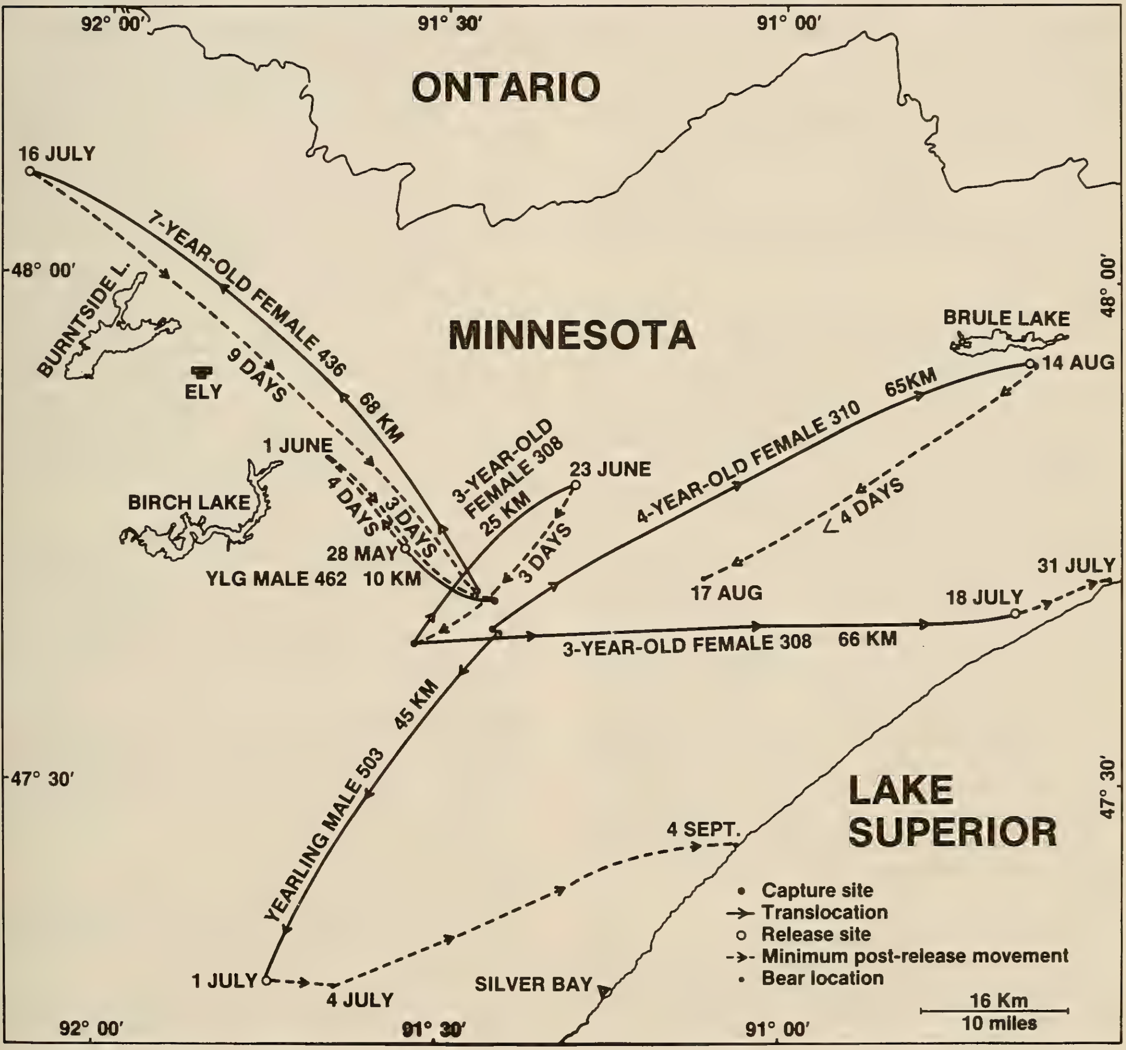

FIGURE 1. Movements of translocated Black Bears in northeastern Minnesota, 1972-1978.

3. Female 308, a littermate of Female 310, was also originally captured as a cub with her mother. She was recaptured and radio-collared as a two-year-old at the edge of her mother's territory on 30 June 1971. From then until she was translocated in June 1972, she was located by telemetry in each of 78 attempts. All those locations and all 43 locations for her mother (see account for Female 310) were in an area 10 km in diameter.

She became a nuisance at a campground and, on 23 June 1972, was captured, drugged, and transported unconscious 25 km to a point 21 km north of any previous radio-location. She had a year-old bullet wound that prevented her from straightening her right front leg. From the release point, the homeward sector (23 degrees wide) covered 6% (23°/360°) of the directions she could have moved. By 1300 h on 26 June, 2.75 days later, she was back at the campground, having averaged at least 8.7 km per day. The wind was behind her the entire return trip.

She was recaptured on 18 July and transported 66 km to a point 61 km east of any previous radio-location. That time, she showed no homing tendency and became a nuisance at a picnic area 11 km farther from home.

4. Male 462 was orphaned as an eight-month-old cub on the outskirts of Duluth, Minnesota, on 8 September 1972 and was transported 112 km northeast to the study area. He adopted the release site as his new range and was radio-collared there two weeks later. During the fall and after emergence from his den in spring, he used an area 4.2 km in diameter (28 telemetry locations) and was seen frequently in a 1 km portion of it where people fed him.

On the evening of 28 May 1973, he was drugged and transported to a point 10 km northwest of any previous radio-location. From the release point, the homeward sector (58 degrees wide) covered 16% (58°/360°) of the directions he could have moved. Four days later, at 1615 h, he was 13 km farther northwest, moving in the wrong direction, but in another three days, by 1900 h on 4 June, he was back in his adopted range, having returned the 23 km from his last location at a speed of at least 7.4 km/day. Wind during his travels was a crosswind except on 30 May and 4 June when it switched to the opposite direction and probably included a period when the wind was from home.

5. Male 503, an orphan, was found in an area 4 km in diameter on 54 of 55 telemetry attempts during his first 1.5 years of life. On 1 July 1974, he was captured as a yearling, his radio-collar was removed, and he was transported 45 km southwest. He was seen three days later 9 km east of the release site and was killed two months later 44 km farther east. He had moved 45 degrees off the homeward direction.

Discussion and Conclusions

The two adults (Females 310 and 436) showed good homing abililty, moving quickly homeward from areas probably 60 km outside their familiar areas. The two yearlings (Males 462 and 403) moved long distances in nonhomeward directions, thereby showing poorer homing ability, as has been shown for young bears in other studies (Harger 1970; Alt et al. 1977; Harms 1980). However, when one of those yearlings, Male 462, eventually turned homeward, he traveled at a speed (7.4 km/day) approaching that of the adults. The crippled subadult (Female 308) was intermediate in that she homed quickly from 25 km but did not move homeward from 66 km.

Wind direction probably did not influence homing success because individuals homed as quickly when moving downwind or crosswind (Females 308 and 310) as when winds were from the home direction (Female 436). This is not to say that olfactory cues were not important for homing; wind-borne cues from any direction could conceivably aid orientation (Ioale et al. 1983; Rogers 1984).

The speeds of return for the two adults (11.4 and 7.5 km/day) were among the fastest on record for Black Bears (Harger 1970; McCollum 1974; Alt 1977; Gunson and Pipella 1977). For comparison, five adult Black Bears that were radio-tracked in Pennsylvania as they moved fairly directly home moved an average of 5.4 km/day (1.5 to 10.8 km/day: Alt 1977). The rapid returns of the two adults in Minnesota indicate fairly direct homeward movement.

Researchers who have studied homing by bears that had not been radio-tracked prior to translocation concluded that the bears were navigating by some means other than familiar landmarks (Harger 1970; Alt 1977; Miller and Ballard 1982). Results of this study support that conclusion.

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Aquatic Angiosperms at Unusual Depths in Shoal Lake, Manitoba–Ontario

EVA PIP and KENT SIMMONS

Department of Biology, University of Winnipeg, Winnipeg, Manitoba R3B 2E9

Pip, Eva, and Kent Simmons. 1986. Aquatic angiosperms at unusual depths in Shoal Lake, Manitoba–Ontario. Canadian Field-Naturalist 100(3): 354–358.

Shoal Lake (elevation 323 m) was found to contain extensive macrophyte communities growing at depths of 12-14 m and consisting of the angiosperms *Elodea canadensis, Najas flexilis, Potamogeton foliosus, P. zosteriformis, Myriophyllum exalbescens, Ceratophyllum demersum, Megalodonta beckii, Zosterella dubia, Lemna trisulca* and the aquatic moss *Drepanocladus* sp. Aside from one previous record for *E. canadensis* at higher altitude, the above angiosperm species have not been reported at such depths before. These communities were observed throughout two consecutive growing seasons. Plants at these depths received an estimated 0.5-1% of surface light. Besides light, other factors which may have allowed for the existence of these communities were warm summer temperatures in deep water and the presence of oxygen in the sediments during most of the ice-free season.

Key Words: Macrophytes, aquatic angiosperms, depth record, Shoal Lake, Manitoba, Ontario.

Submerged aquatic vascular macrophytes are normally confined to shallower regions of lakes, where light penetration and temperature, in conjunction with other, less well understood factors are conducive to macrophyte growth and reproduction. Normally angiosperms do not occur at depths greater than 10 m in freshwater (Ruttner 1953; Sculthorpe 1967; Hutchinson 1975). Recently Sheldon and Boylen (1977) and Singer et al. (1983) have recorded angiosperms at greater depths but these records apply to acidified lakes of exceptional clarity (ultraoligotrophic), where very little phytoplankton is present to reduce light penetration to deeper strata.

The present paper reports the existence of a diverse established macrophyte community at the unusual depths of 12-14 m in Shoal Lake, a large, nonacidified Precambrian Shield lake on the Manitoba–Ontario boundary. Shoal Lake has a mean elevation of 323 m above sea level and is the source of the water supply for the City of Winnipeg.

Materials and Methods

Sampling was conducted on a semi-monthly or monthly basis during the 1984-5 growing seasons. A set of samples was also collected under ice cover in late February 1985. Water samples were immediately placed on ice in a dark container and frozen within 7 hours. Deep water samples were obtained with a van Dorn sampler. Thawed samples were analyzed according to methods recommended by the American Public Health Association (1975, 1985). Nitrate was determined using an Orion Ionalyzer model 407A with nitrate electrode. The pH was measured directly in the field with a portable pH meter.

Photosynthetically active radiation (PAR) [400-700 nm] was measured using a Li-Cor Integrating Quantum Photometer equipped with an underwater quantum sensor. Temperature and dissolved oxygen were measured with a Yellow Springs Instruments Tele-thermometer and Oxygen Meter, respectively.

Chlorophyll content of water was estimated by filtering 0.2 to 1 L of water in the field through Whatman No. 1 filter paper under suction from a hand vacuum pump. The filter was placed in a plastic bag on ice in darkness, and stored in the laboratory at -20°C in the dark. The filter was ground in a mortar with neutralized acid-washed silica sand and 15 mL 80% acetone containing 10 mM $CaCO_3$ (lime). The homogenate was centrifuged at low speed in a clinical centrifuge. Chlorophyll content of the supernatant was determined using the spectrophotometric method of Arnon (1949).

Standing crop of the deep communities was estimated with the aid of SCUBA; all above-ground plant material was collected by hand within a randomly chosen circle of 20 m radius, and washed and dried at 70°C to constant weight.

Results

The unusually deep macrophyte communities were distributed over a large area, centered at approximately 49°36′N, 95°04′W, near the entrance to Indian Bay of Shoal Lake. This location is henceforth referred to as the DW site. The ranges of chemical and physical parameters obtained at this site during the 1985 growing season are given in Table 1. Most water chemistry parameters showed a wide range of variation during the season, particularly for phosphorus and nitrate concentrations. Amounts of chlorophyll a in the water, indicative of phytoplank-

TABLE 1. Chemical and physical parameters for the DW site at the surface and at depths of 11-12.5 m during 2 May-29 August 1985.

Parameter	Surface	11–12.5 m	Sediments at 12–14 m
pH	6.9–8.0	6.9–7.8	
Total dissolved solids, mg L^{-1}	45–108	52–85	
Total alkalinity, mg L^{-1} $CaCO_3$	62–83	64–88	
Phosphorus (molybdenum reactive), mg L^{-1}	0.07–0.85	0.10–0.91	
Nitrate-N, mg L^{-1}	0.09–> 1.0	0.05–0.7	
Nitrite-N, mg L^{-1}	0–0.001	0–0.002	
Ammonia-N, mg L^{-1}	0–0.05	0–0.05	
Sulphate, mg L^{-1}	1.4–3.1	1.4–3.8	
Chloride, mg L^{-1}	0	0	
Dissolved oxygen, mg L^{-1}	8.9–11.8	5.0–10.4	0–10.6
Chlorophyll a, μg L^{-1}	1.6–> 6	2.6–5.6	
Temperature, °C	8–20.5	5–19	4–16.5
Light, as % of surface	–	0.7–2.5*	
Light, as μE $s^{-1}m^{-2}$	175–2370	2–42*	

*at 10 m; range from full sun to heavy overcast.

ton biomass, attained the highest values in August, when inorganic nutrient levels and temperatures were also high. The phytoplankton communities at the DW site were dominated by diatoms, although bluegreen, green, chrysophycean and dinoflagellate algae were also well represented.

Thermal stratification was generally not very pronounced because of the large surface area relative to volume of the lake, although localized thermoclines of limited duration could occur. Temperature attenuation at the DW site was slight during the ice-free season, even during periods of calm in midsummer, with a maximum observed difference of 5° C between the surface and the bottom of the water column. Water temperatures at 12-14 m varied from 4° C in winter to a recorded late summer maximum of 19° C in 1984 and 17-19° C in 1985.

Dissolved oxygen levels in the sediments approached 0 mg L^{-1} under February cover of 0.75 m ice and 0.5-0.75 m snow, but a week after the ice disappeared in late April, sediments at the DW site contained approximately 90% of surface dissolved oxygen levels. Sediment oxygen concentrations then declined steadily; in mid- July they were still 7.5% of those at the surface. A minimum of close to 0 was observed at the beginning of August, but values had increased again to > 25% by the end of August.

Midday surface incident PAR intensities showed a wide range, depending on degree of cloud cover. A large part of incident PAR (up to 70%) was lost in the first meter of water. Light intensities at 13-14 m were estimated at 0.5-1% of surface incident levels. Attenuation depended largely on phytoplankton density, while the amount of light penetrating below the surface was subject to variations in surface reflection resulting from differences in smoothness of the water surface and the angle of incidence at different times of the season.

A total of 32 aquatic macrophyte species was recorded in Shoal Lake. The macrophyte communities in shallower waters of this lake have been described by Pip and Sutherland-Guy (*in press*). The communities at 12-14 m at the DW site still contained a surprising array of vascular species: *Elodea canadensis* (Common Elodea), *Najas flexilis* (Common Naiad), *Potamogeton foliosus* (Leafy Pondweed), *P. zosteriformis* (Flatstem Pondweed), *Myriophyllum exalbescens* (Northern Watermilfoil), *Ceratophyllum demersum* (Coontail), *Megalodonta beckii* (Water Marigold), *Zosterella dubia* (Water Stargrass) and *Lemna trisulca* (Star Duckweed). A nonvascular aquatic moss, *Drepanocladus* sp., was present as well. Except for *C. demersum* and *L. trisulca*, which are species that have no roots, all other angiosperms were firmly rooted in the sediments and were observed by the diver to be present throughout the entire growing season. The sediments in the area were light and flocculent, with a high organic matter content (25% or more by dry weight). They were easily suspended by even slight water disturbance, yet the diver never observed any turbulence at the site other than that caused by his own movements. Although these communities were established over a wide area during both 1984 and 1985 (at least a hundred thousand square meters), they were very sparse, appearing as individual shoots anchored in shallow depressions in the bottom sediments. Standing crop in mid-July 1985 was estimated at 0.001 g m^{-2} dry weight

(compared to values as high as 916 g m^{-2} in water 1 m deep in the same lake (Pip and Sutherland-Guy, *in press*)). The most widespread species at these depths appeared to be *E. canadensis*; other species showed irregular, patchy distributions. Chlorophyll composition of these plants has been examined elsewhere (Pip and Sutherland-Guy, *in press*)). Representative voucher specimens have been deposited in the University of Winnipeg herbarium.

Discussion

The depth limits at which different macrophytes occur in a given lake depend in large part on the amount of light penetration (e.g. Crum and Bachmann 1973; Riemer 1984), since the light compensation point (i.e. the light intensity at which photosynthetic carbon gain equals respiratory loss) for a given species will occur at a greater depth where water is more transparent. Thus depth limits must be qualified by measuring the percentage of surface illumination that actually reaches the plants.

In general it is known that some macrophytes may extend to depths which receive only 1-4% of surface light (Sculthorpe 1967), although many macrophytes appear to require much higher minimum intensities. Several of the macrophyte species recorded in the deep communities in Shoal Lake seemed to tolerate much lower light intensities than the minimum values reported for the same species by other workers. For example Wilson (1941) found that *Megalodonta beckii* required at least 10% of surface light in Trout Lake, Wisconsin, while Blackburn et al. (1961) suggested that *Zosterella dubia* under laboratory conditions required at least 18% of full summer sun for good growth. Wilson (1941) also reported minimum values of 4.5% for *Elodea canadensis* and 3.1% for *Najas flexilis*. However, the bottom light intensities of 0.5-1% at the DW site were still apparently adequate for the growth of nine vascular species, which may have adapted over time to the low light intensities. Some plants are indeed known to be capable of growth at light levels of less than 1%. For example, Blackburn et al. (1961) found experimentally that *Elodea densa* (South American Elodea) can still grow well at approximately 0.3% of full summer sun. Variability in the amounts of light required by a given species in different situations has been noted in other comparisons as well and it has been suggested (e.g. Hutchinson 1975) that other factors may be operating in addition to light to determine lower depth limits for macrophytes in individual lakes.

The maximum depth of occurrence for vascular macrophytes (i.e. angiosperms) in nearly all lakes, even in very clear waters with excellent light penetration, is generally not more than 10 m (Sculthorpe 1967; Hutchinson 1975). On the other hand nonvascular plants, such as *Chara, Nitella* and aquatic mosses, which were all represented in Shoal Lake as well, may achieve considerably greater depths (Hutchinson 1975). Among the factors that have been proposed to account for this difference is the effect of hydrostatic pressure on growth and development of plants which contain an internal system of lacunar spaces filled with gas (e.g. Ruttner 1953; Hutchinson 1975). Such spaces are lacking in nonvascular macrophytes. Ferling (1957) found that excess pressure may cause abnormal development in some macrophytes, although of the species he examined, *Elodea canadensis* appeared to withstand high pressures better than *Groenlandia densa* or *Ranunculus circinatus*. Bodkin et al. (1980) reported that some macrophytes, such as *Hippuris vulgaris* (Marestail), may grow normally at pressures corresponding to depths of 13 m, provided that high light intensities (100 $\mu E\ s^{-1} m^{-2}$) are maintained.

The 12-14 m depth records for Shoal Lake are of great interest since they represent the first records of rooted angiosperms at such depths in both a nonacidified lake and at fairly low altitude. Reduced atmospheric pressure in lakes at higher altitudes compensates to some extent for increased hydrostatic pressure at greater depths (Hutchinson 1975). Dangeard (1925) reported *E. canadensis* and *Najas marina* at 12-15 m in Lac d'Annecy in the French Alps. Despite the elevation of this lake, this record has previously been considered doubtful (e.g. Hutchinson 1975). Other records for angiosperms at comparable depths are those of Sheldon and Boylen (1977), who reported *E. canadensis* at 12 m in Lake George, New York, and Singer et al. (1983), who found *Potamogeton robbinsii* (Fern Pondweed) at 14 m in Lake George, and *Utricularia geminiscapa* (Hidden-flower Bladderwort), a rootless species, growing at 18 m in Silver Lake, New York. These latter two lakes are acidified and phosphorus-poor, with high sulphate and nitrate levels and low pH. Singer et al. (1983) suggested that in Silver Lake (elevation 641 m), extreme water clarity was an important factor which contributed towards the unusually deep growth of macrophytes.

Water clarity in Shoal Lake was not exceptional. Values for pH, total alkalinity and phosphorus were much higher during most of the season than the values given by Singer et al. (1983) for Silver Lake. Chlorophyll a values at the study site were also substantially greater than the August value of 0.11-0.14 $\mu g\ L^{-1}$ reported for Silver Lake. In Lake George as much as 10% of surface light was still available at 12 m (Sheldon and Boylen 1977). These differences are all the more remarkable in that all previous

records of deep water angiosperm communities each involved at most only two species of macrophytes.

Sheldon and Boylen (1977) pointed out that in many lakes the lower boundary for angiosperm growth corresponds to the maximum penetration of the summer thermocline. Differences in temperature at different depths may be significant enough to limit the length of the growing season in deeper waters (Moeller 1980). At low temperatures the ability of macrophytes to use available light for photosynthesis is reduced (Barko et al. 1982). Pokorny et al. (1984) reported that the optimum temperature for photosynthesis in *E. canadensis* at low irradiance levels is 20°C, which is near the maximum late summer temperatures of 17-19°C observed at 12-14 m at the DW site. Singer et al. (1983) also suggested that in Silver Lake, warm deep water with no thermal stratification (18.7°C in late August) was a key factor allowing for deep macrophyte growth.

The generally high content of sediment organic matter in Shoal Lake is interesting in that Barko and Smart (1983) have reported that organic material can inhibit growth of submergerd species, particularly in anaerobic sediments, where many toxic compounds may be generated. According to Armstrong (1978), ability of macrophytes to tolerate such compounds may be associated with efficient transport of oxygen from shoots to roots to assist in detoxification. It is here that the internal lacunar system may be important (Williams and Barber 1961). The sediments of Shoal Lake at 14 m contained some oxygen during much of the growing season. Thus sediment toxicity was reduced. This may have been an additional factor which permitted macrophytes to penetrate into deeper waters. The 12 m record for *E. canadensis* reported for Lake George by Sheldon and Boylen (1977) was also associated with aerobic sediments.

In conclusion, a combination of factors probably operates in Shoal Lake to allow macrophytes to colonize depths beyond those normally utilized in most water bodies. These factors may have been sufficient light intensities, warm deep water, and presence of oxygen in the sediments. Hydrostatic pressure did not appear to be important, since Shoal most water bodies. These factors may have been sufficient light intensities, warm deep water, and presence of oxygen in the sediments. Hydrostatic pressure did not appear to be important, since Shoal Lake is at a lower elevation than any other previously reported lake containing deep water comunities. These observations support the contention of Singer et al. (1983) that it is inaccurate to view depth limitation in a given water body as the product of only a single variable.

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Observations of Moose, *Alces alces*, in Peripheral Range in Northcentral Minnesota

TODD K. FULLER

Forest Wildlife Populations and Research Group, Minnesota Department of Natural Resources, Grand Rapids, Minnesota 55744

Fuller, Todd K. 1986. Observations of Moose, *Alces alces*, in peripheral range in northcentral Minnesota. Canadian Field-Naturalist 100(3): 359–362.

Moose (*Alces alces*) and Moose sign were observed during November-May 1981-1985 in and near a 839 km² area in northcentral Minnesota that is on the periphery of Moose range in the state. Data from aerial surveys in winter and pellet group counts in spring conducted primarily to determine numbers of White-tailed Deer (*Odocoileus virginianus*; density about 8/km²) indicated a winter Moose density of only 2/100 km². During winter (November-February), calves constituted 15 of 63 (24%) Moose seen; 44% of adults were bulls. No evidence of Wolf (*Canis lupus*) predation on Moose was found, but Wolves scavenged carcasses of at least seven Moose (aged 1.5–10.5 years) that probably died of other causes. Most deaths of Moose ≥ 6 months old likely were due either to deer hunters or to the brainworm *Parelaphostrongylus tenuis*, a nematode parasite. Adult worms were found in the brain of a dead 10-month-old calf, and first-stage larvae occurred in 30 of 37 (81%) deer pellet samples collected in the study area.

Key Words: Moose, *Alces alces*, White-tailed deer, *Odocoileus virginianus*, Wolf, *Canis lupus*, density, mortality, population parameters, *Parelaphostrongylus tenuis*, Minnesota.

Historically, Moose, *Alces alces*, occurred throughout the forested portion of Minnesota. Fluctuations in Moose numbers have been attributed to changes in White-tailed Deer, *Odocoileus virginianus*, numbers and, concomitantly, to the meningeal worm *Parelaphostrongylus tenuis*, the etiological agent of Moose disease (Karns 1967, 1977; Karns et al. 1974). Few Moose population data have been gathered in Minnesota outside the Moose's primary range (Figure 1), especially where deer numbers are high and Moose numbers are low. Observations of Moose were recorded while conducting extensive radiotelemetry studies of Wolves, *Canis lupus*, and White-tailed Deer in peripheral Moose range in northcentral Minnesota during 1981-1985. This note presents estimates of Moose population density, and winter sex and age ratios, and examines Moose mortality caused by *P. tenuis*, Wolves and deer hunters.

Study Area

Observations were made in and to the south of the 9 township (839 km²) Bearville Study Area (BSA) in northeastern Itasca County, Minnesota (93°15′N, 47°45′W) (Figure 1). Vegetation is mostly boreal coniferous–hardwood forest (Maycock and Curtis 1960), with uplands dominated by aspen (*Populus* spp.), Balsam Fir (*Abies balsamea*), Paper Birch (*Betula papyrifera*), and Jack Pine (*Pinus banksiana*), and lowlands covered mainly with Black Spruce (*Picea mariana*), Tamarack (*Larix laricina*), and Black Ash (*Fraxinus nigra*)(Mooty 1979).

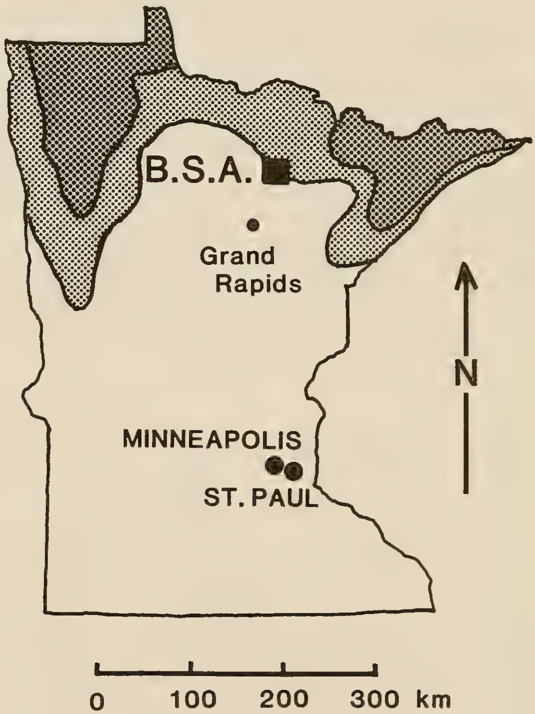

FIGURE 1. Distribution of Moose (shaded) in northern Minnesota and the location of the Bearville Study Area (BSA). Heavily shaded areas indicate primary Moose range (Karns et al. 1974; P. D. Karns, personal communication).

In Grand Rapids, 50 km southwest of the study area, the mean January temperature is -14°C and the July mean is 19°C (U. S. Dept. of Commerce, unpublished data). Snow cover usually is present from early December through early April, and the January-March snow thickness averages 40 cm.

Methods

Population estimates of Moose were derived from aerial surveys and pellet group counts conducted in the BSA during 1981-1985 primarily to estimate numbers of White-tailed Deer. Aerial surveys were flown in a Cessna 172 at 100–130 m above ground level and at 110–130 km/h with two observers on the right side of the aircraft. Searches were conducted on the same 36 2.6-km² quadrats each year; initially four quadrats were randomly selected in each of the 9 townships (11% coverage). Six to nine additional quadrats that might have contained marked deer were also searched each year. The search pattern consisted of flying clockwise in overlapping concentric circles to cover the entire quadrat; search time averaged about 6 min/km². We assumed that 68% of Moose present on plots were counted (LeResche and Rausch 1974) and corrected density estimates accordingly.

Moose pellet groups were counted during searches for deer pellet groups (Ryel 1971; Mooty et al. 1984) between April and May each year. Linear courses were selected randomly within stratifications set up for deer surveys. On each course, 4 plots (22.1 m × 3.7 m each) were set a standard distance apart each year; among years this standard distance ranged from 140 to 300 m. Moose density was calculated using defecation rate (17 groups/Moose/day; Franzmann et al. 1976; Oldemeyer and Franzmann 1981), deposition period (mean number of days between leaf fall and pellet counts = 182 days), and plot size; no correction was made for moose dying overwinter.

Winter sex and age composition of the Moose population was determined from incidental observations made during Wolf and deer radiotelemetry flights, and during aerial surveys of deer hunters in November and of deer in January and March. Anterless Moose were sexed by the presence or absence of a vulval patch (Mitchell 1970). Moose carcasses were found during radiotelemetry flights for Wolves or through reports from the public, and all were visited on the ground.

Adult *P. tenuis* were found by dissecting Moose crania and first-stage larvae were found by examining fecal pellets (Karns 1967, 1977) collected mostly from deer live-captured in winter.

Results

Only 1–3 Moose were seen during each aerial survey but estimated densities were similar and averaged 2.0 Moose/100 km² (Table 1). Only 0–3 Moose pellet groups were counted during each pellet group survey, but again projected Moose densities were similar each winter and averaged close (2.5 Moose/100 km²) to those from the aerial deer surveys. In spring 1981, we also counted Moose pellet groups in the six townships immediately south of the BSA and estimated a density of 1.9 Moose/100 km² (N = 205 plots).

During November-March, we observed 63 Moose from the air, 15 (24%) of which were calves. One cow was seen with triplets, two with twins, seven with single calves, and nine with no calves; one calf was seen with a bull but no cow was present. Sixteen (44%) of 36 adults of known sex were bulls.

We examined carcasses of nine Moose, all during November-May. Seven of the Moose were females (aged 0.5, 1.5, 1.5, 2.5, 3.5, 6.5 and 10.5 years) and two

TABLE 1. Population estimates for Moose in the 839-km² Bearville Study Area in northcentral Minnesota.

	Aerial survey			Pellet group counts		
Year	No. of plots searched	No. of Moose seen	Estimated density[a] (No./100 km²)	No. of plots searched	No. of groups counted	Projected Moose density (No./100 km²)
1981				250	2	3.2
1982	42	1	1.4	257	0	0.0
1983	45	1	1.3	281	1	1.4
1984	45	1	1.3	257	2	3.1
1985	43	3	4.0	252	3	4.8
		Mean ± 1 SD =	2.0 ± 1.3		Mean ± 1 SD =	2.5 ± 1.8

[a]Corrected for 68% sightability (LaResche and Rausch 1974).

were males (aged 2.5 and 5.5 years). Both males bore antlers, indicating that they died in fall or early winter. Seven moose carcasses were located when radiocollared wolves scavenged them, and one was reported by local residents after it had been illegally shot during the firearms deer season in November. The calf died in February after exhibiting behavior typical of *P. tenuis* infection (Anderson 1965a,b). Necropsy revealed the presence of *P. tenuis* in the tissue of the calf's brain.

Thirty (81%) pellet samples collected from 37 different deer during winter in the BSA contained first-stage larvae of *P. tenuis*.

Discussion

It does not appear that poor reproduction is limiting Moose numbers in the BSA. The proportion of calves in the winter population (24%) was similar to that in a well-established Moose population in northwestern Minnesota ($\bar{X}$ = 25%; 1972-80) and greater than that in northeastern Minnesota ($\bar{X}$ = 15%; 1972-80) (Berg 1980).

P. tenuis may limit Moose numbers in forested areas with sympatric Moose and White-tailed Deer populations (Karns 1967, 1977; Gilbert 1974); *P. tenuis* is not normally lethal to White-tailed Deer. In areas where deer densities are high, the incidence of the brain worm is also high, increasing the chances that Moose will be affected. *P. tenuis* likely killed a calf Moose in the study area and the prevalence of *P. tenuis* in deer pellet groups there (81%) is higher than has been reported elsewhere in Minnesota (Karns 1977), suggesting that Moose could be seriously affected.

Moose are legally protected in and near the study area, and though we examined only one hunter-killed Moose during this study, one other Moose mistaken for a deer was known to have been shot and several others are suspected to have been shot and not reported.

Scat analyses revealed no evidence of Moose calf predation in summer by Wolves in the BSA (T. K. Fuller, unpublished data). In addition, radiomarked Wolves in the study area located at over 100 carcasses of freshly-killed White-tailed Deer were never found on the fresh carcass of a Moose. Thus Moose scavenged by Wolves probably were not killed by them, but were shot by hunters in fall or died from *P. tenuis* infection.

Density of Moose in their primary range in Minnesota has recently ranged from 10-70 Moose/100 km^2 (Karns 1983); deer densities in the same areas average 1–6/km^2 (Minnesota Department of Natural Resources files). In the BSA, where deer densities average about 8/km^2, Moose densities are about 2/100 km^2. Karns (1967) suggested that on areas managed primarily for Moose, deer densities should be $<5/\text{km}^2$. The data from the BSA support this contention.

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Wolf, *Canis lupus*, Distribution on the Ontario–Michigan Border Near Sault Ste. Marie

WILLIAM F. JENSEN,[1] TODD K. FULLER,[2] and WILLIAM L. ROBINSON

Department of Biology, Northern Michigan University, Marquette, Michigan 49855
[1]Present address: Department of Biology, University of North Dakota, Grand Forks, North Dakota 48202
[2]Present address: Forest Wildlife Populations and Research Group, Minnesota Department of Natural Resources, Grand Rapids, Minnesota 55744

Jensen, William F., Todd K. Fuller, and William L. Robinson. 1986. Wolf, *Canis lupus*, distribution on the Ontario–Michigan border near Sault Ste. Marie. Canadian Field-Naturalist 100(3): 363–366.

Wolf (*Canis lupus*) distribution was determined on the Ontario–Michigan border near Sault Ste. Marie, Ontario from government records, interviews with local residents, and aerial and ground surveys during 1980-1981. Breeding packs occurred only in Ontario, and except for Cockburn Island, only lone Wolves were found in areas close to the border or in Michigan. In Ontario, road density in areas not occupied by Wolves ($\bar{X}$ = 0.93 km/km^2) was greater than in areas occupied by Wolves ($\bar{X}$ = 0.38 km/km^2). Mean road density in Michigan where no Wolves reside ($\bar{X}$ = 0.69-0.84 km/km^2) was also greater than in Wolf-occupied areas of Ontario. High human densities, as indicated by road densities of $>$ 0.6 km/km^2, apparently serve as a barrier to Wolf dispersal into Michigan. An evaluation of road densities, in conjunction with other factors, may aid in estimating the impact of development on established Wolf populations, or in predicting the likelihood of re-establishing Wolves in an area.

Key Words: Wolf, *Canis lupus*, distribution, road density, Michigan, Ontario.

In the United States, outside Minnesota, the Wolf (*Canis lupus*) is designated as endangered under the Endangered Species Act of 1973, but it remains unprotected and plentiful in many parts of Canada. Only along a few segments of the Canada–U.S. border, however, are Canadian Wolf populations large enough to replenish depleted numbers in endangered populations by movements across the border. In the Rocky Mountains, an occasional Wolf moves into northern Montana and Idaho from Alberta and British Columbia (Ream and Mattson 1982). Another potential area of international movements of Wolves exists in the eastern Lake Superior–St. Mary's River region (Figure 1).

Since the mid-1950s, single Wolves or pairs have occurred in the Upper Peninsula (UP) of Michigan (Hendrickson et al. 1975; Weise et al. 1975; Robinson and Smith 1977), but no evidence of breeding has been found. In contrast, Wolves are harvested annually in adjacent Ontario east and north of Whitefish Bay in Lake Superior or the St. Mary's River. Knowledge of Wolf distribution in this area may assist managers in assessing the probability of Wolves' re-establishing themselves in the UP and provides an historical basis for comparison of Wolf distribution in the future. This paper reviews recent records of Wolves in the eastern UP, describes Wolf distribution in Ontario near the Michigan border during 1980-81, and evaluates road densities as an indicator of Wolf distribution.

Methods

We estimated the number and distribution of Wolves in the Whitefish Bay–St. Mary's River area (46°30′S, 84°40′E) by reviewing technical literature and the records of the Ontario Ministry of Natural Resources (OMNR) and the Michigan Department of Natural Resources (MDNR), interviewing OMNR and MDNR personnel, trappers, and other local residents, and conducting aerial and ground surveys during winters 1979-80 and 1980-81.

During 15 January-22 March 1980 and 10 January-26 March 1981, aerial searches (Fuller and Robinson 1982) for Wolf tracks were conducted along the Canadian shoreline for 39 hours (25 flights) and 27 hours (14 flights), respectively. Approximately 165 and 236 km, respectively, were traversed on the ground in adjacent forested areas during the two winters. No surveys were conducted within the city limits of Sault Ste. Marie, Ontario (population : 85 000) or Sault Ste. Marie, Michigan (population : 15 000).

Individual packs in Ontario were identified by grouping adjacent reports and track observations of similar numbers of Wolves, and the southern boundary of pack distribution was delineated. The locations of lone Wolves were noted, but they were not considered when the occupied Wolf range was detailed.

After determining the limit of Wolf pack distribution, we measured and mapped densities of all roads, both surfaced (all-weather) and unsurfaced

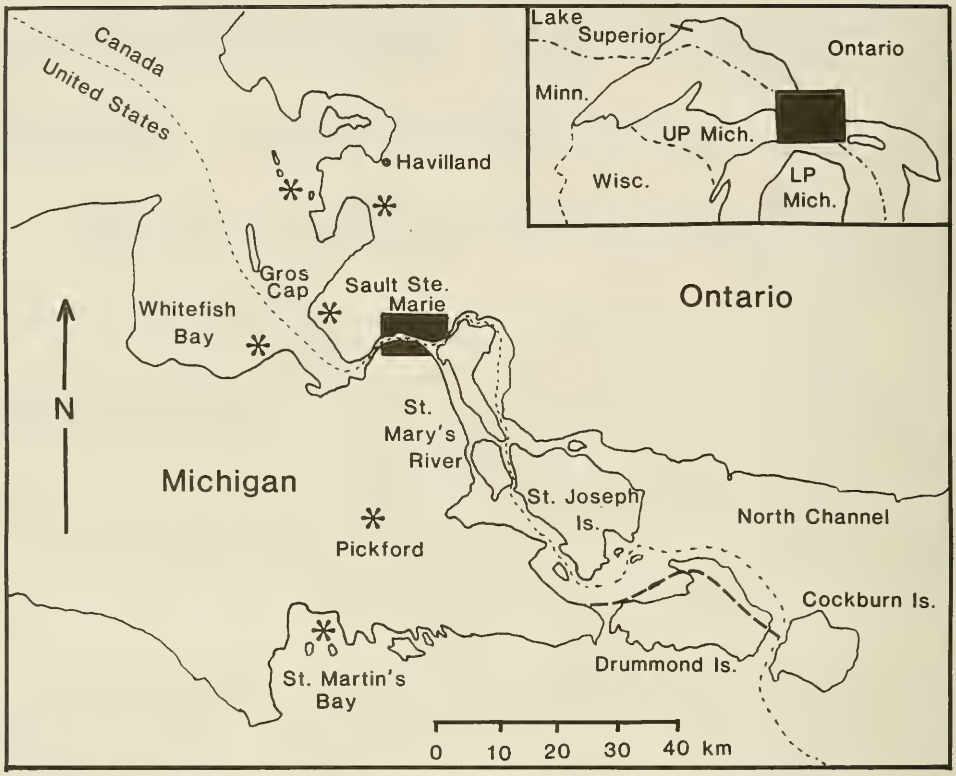

FIGURE 1. The Whitefish Bay – St. Mary's River Study Area on the Michigan–Ontario border. Asterisks and the heavy dashed line denote the location of recent Wolf and Wolf track observations discussed in the text. The dotted line indicates the international boundary.

(dry-weather and trails), by township (usually 80-120 km² each) in about 11 000 km² in Ontario and the UP (Figure 2) from provincial maps (1970, 1977 and 1978, scale = 1:126 720) and the Chippewa and Mackinac County atlas and plat books (1977, scale = 1:56 320). Areas within the city limits of Sault Ste. Marie, Ontario and Michigan were excluded from these measurements.

Results

The most recent Wolf specimens from the eastern UP were killed in 1967 on St. Martin's Bay, in 1968 on the south end of Whitefish Bay, and in 1972 near Pickford (Figure 1) (Hendrickson et al. 1975). Since 1968, only nine confirmed sightings of Wolves have been made in Michigan within 70 km of Ontario (MDNR files).

Interviews with OMNR personnel, trappers, and local residents indicated that during winter 1980-81, about seven packs or pairs totalling perhaps 20-25 Wolves, as well as several lone Wolves, resided within 25-50 km of the Whitefish Bay–St. Mary's River shoreline (Figure 2). Each winter, 5 to 10 Wolves are trapped in the area (OMNR files). During the fall seasons of 1978 to 1981, E. Mitchell (local trapper, personal communication) trapped one, two, three, and one Wolf, respectively, on Cockburn Island before freeze-up, indicating that a pack lived there also.

Interviewed persons indicated that no Wolves permanently resided in the settled areas just north of the St. Mary's River, the North Channel, and Sault Ste. Marie, Ontario, and only single Wolves or an occasional pack travelled in the area just east of Whitefish Bay. These observations confirmed results of our aerial and ground surveys. Five probable Wolf tracks were observed from the air on Whitefish Bay, 6 km from the Ontario mainland, single Wolf tracks were found 5 km south of Havilland and near Gros Cap, Ontario, and tracks of two Wolves crossed the ice from St. Joseph Island, Ontario to Drummond Island, Michigan, then headed for Cockburn Island, Ontario (Figure 1).

The southern and western limits of Wolf pack

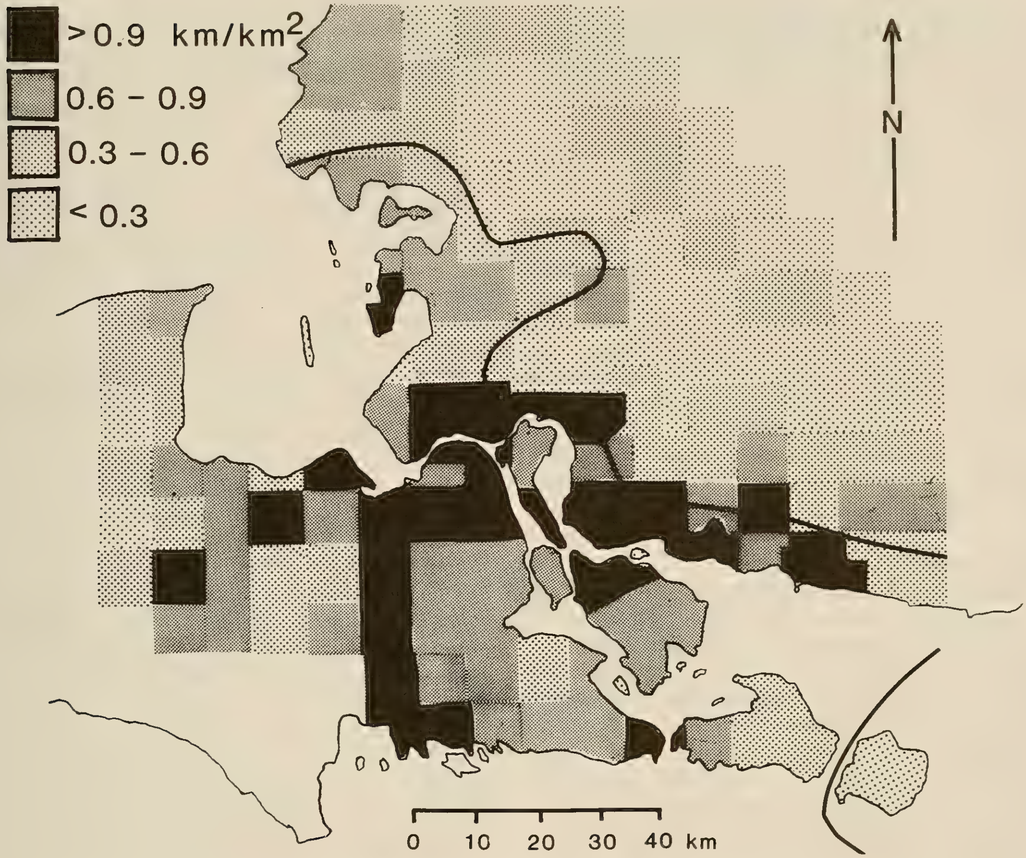

FIGURE 2. Distribution of road density (surfaced and unsurfaced), by township, in the Whitefish Bay–St. Mary's River Study Area. Solid line indicates the southwestern limit of the distribution of Wolf packs in the area.

distribution generally corresponded to areas where mean road density exceeded about 0.6 km/km^2 (Figure 2). In the Ontario portion of the study area, road density within areas not occupied by Wolves ($\bar{X}$ = 0.93 km/km^2) was greater than in Wolf-occupied areas ($\bar{X}$=0.38 km/km^2). Mean road density in Michigan for townships within 40 km of the St. Mary's River (0.84 km/km^2) was also greater than in Wolf-occupied areas of Ontario, and similar to unoccupied areas in Ontario. Road density in areas > 40 km from the St. Mary's River ($\bar{X}$ = 0.69 km/km^2) was less than nearer the river (Figure 2), but still higher than in Wolf-occupied areas of Ontario.

Discussion

Large tracts of wild land with low human densities and minimal accessibility must be available if a Wolf population is to be maintained or re-established in an area (Bailey 1978; Henshaw 1979; Mech 1979). Quantitative evaluation of the relationship between human activities and Wolf distribution is therefore essential to management efforts. Human census data have been used to identify potential Wolf range (Weise et al. 1975; Henshaw 1982), but such information may not be sufficiently current or area-specific for management. Thiel (1985) correlated the historical demise of Wolves in Wisconsin with increasing road densities, and thus presumably with human exploitation rates. Roads, besides indicating loss of habitat, result in increased mortality from trapping, shooting, and collisions with vehicles. In areas where up-to-date, large-scale road maps are easily available, correlations between road densities and Wolf densities could facilitate evaluations of Wolf habitat.

The distribution of Wolf packs north and east of

Sault Ste. Marie, Ontario is most likely determined by rates of human exploitation, since the OMNR allows year-round trapping and supervises trapping to reduce livestock depredations by Wolves (S. Jones, OMNR, personal communication). In addition, the settled areas along the St. Mary's River likely act as a barrier to Wolf emigration. In Michigan, where Wolves are protected as an endangered species, most Wolf mortality is likely caused by humans as well (Weise et al. 1975; Robinson and Smith 1977).

Both this study and the work of Thiel (1985) indicate that where road densities exceed about 0.6 km/km^2, Wolf populations cannot sustain themselves. Though official definitions of roads may vary between areas, the available data suggest that by evaluating road density one might obtain a preliminary estimate of the impact of development on already established Wolf populations, or of the likelihood of re-establishing Wolves in areas otherwise appropriate.

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Observations on the Reproductive Ecology of the Crescent Gunnel, *Pholis laeta*, from Marine Inshore Waters of Southern British Columbia

GRANT W. HUGHES

Aquatic Zoology Division, British Columbia Provincial Museum, 675 Belleville Street, Victoria, British Columbia V8V 1X4

Hughes, Grant W. 1986. Observations on the reproductive ecology of the Crescent Gunnel, *Pholis laeta*, from marine inshore waters of southern British Columbia. Canadian Field-Naturalist 100(3): 367–370.

Field and laboratory observations of *Pholis leata* (Pisces: Pholididae) demonstrated that reproduction occurred during winter months in intertidal and subtidal rocky areas at Patricia Bay, Vancouver Island, British Columbia. The species exhibits sexual dimorphism, pairing of mates under stones or rocks, and guarding of the developing eggs. Pairing occurred at least one month before egg laying, suggesting that extended courtship may be necessary to coordinate spawning.

Key Words: *Pholis laeta*, Crescent Gunnel, reproduction, British Columbia.

Although reproduction is essential to ensure propagation of species, and the study of reproductive ecology may reveal much about the evolution of life history strategies, modes of reproduction of comparatively few fish species are known in detail (approximately 10% of all fish species surveyed by Breder and Rosen (1966)). In pholidids, more is known of the reproductive behaviour of *Pholis gunnellus* than of any other species in the genus (see Gudger 1927; Qasim 1956; and general references such as Norman and Greenwood 1963; Breder and Rosen 1966; Leim and Scott 1966). Data on *P. ornata* (Fitch and Lavenberg 1975) and a brief reference to the coiling of two *P. laeta* around an egg mass (Marliave and DeMartini 1977) provide comparative information about *Pholis* species from the Pacific coast of North America. In conjunction with a comparative study of the ecology of *P. laeta* and *P. ornata* (Hughes 1985), a study of the breeding biology of *P. laeta* was conducted which investigated seasonality, location, secondary sex characteristics, mating and parental care of *P. laeta*. Results of this study are discussed and compared to reproductive behaviour of other *Pholis* species.

Materials and Methods

The study was conducted at Patricia Bay, Vancouver Island, British Columbia (48°39.2′N, 123°26.8′W, described in Hughes (1985)). In this area a breakwater has been constructed from rocks, cobble and stones with the bottom layer resting on sand and small pebbles. Specimens were collected by hand from under rocks in the intertidal zone and by scuba from depths to approximately 5 m below zero tide during winter months of 1980-82. Although fish were searched for within the interstitial spaces between stones and cobble, specimens were found only under the stones and rocks actually resting on the substrate of sand and pebbles.

Five pairs of maturing *P. laeta* were collected on 9 December 1980 and each pair was placed in a separate aquarium (0.3 m × 0.3 m × 0.5 m with undergravel dolomite filtration and a constant water temperature of 6°C). Cover was provided by transparent 5 mm thick acrylic sheets supported 20 mm or so above the dolomite which simulated the smooth stones under which fish were found, but still enabled viewing from above. Aquaria were covered with black plastic to simulate the darkness of "underneath rock" habitat, although a minimal amount of light entered when observations were made at 0730, 1230 and 1730 h. Fish were not fed until after eggs hatched, since it was assumed that little feeding would occur in the wild during courtship and egg guarding periods.

One hundred and seventeen specimens collected on dates other than 9 December 1980 were examined for maturity, fecundity and sexual dimorphism.

Results

Habitat

Both mature and juvenile *P. laeta* were abundant in intertidal and shallow subtidal rocky areas during the months of November-April. Usually one mature male and one mature female were found under a rock although two pairs were found under one larger (> 0.3 m) rock (see Table 1). Immature *P. laeta* and *Anoplarchus purpurescens* were also observed under the same rock as mature *P. laeta*. Subtidal scuba collecting on 29 February 1980 yielded adult (N = 26) and juvenile (N = 15) specimens from cobble and stone habitat. No ripe specimens were taken.

Breeding Coloration

Sexual dichromatism was evident during winter

TABLE 1. Frequency of occurrence of *P. laeta* collected January, February, November and December 1980 prior to spawning in rocky intertidal habitat of Saanich Inlet, British Columbia.

Number of *P. laeta* present			
Mature male	Mature female	Immature	Frequency
1	1	0	21
2	2	1	1
1	1	1	2
1	1	2	2
0	1	0	1
1	0	2	1
0	0	1	1

months as mature males [100 mm standard length (SL)] exhibited an orange or reddish coloration along the cheeks, throat, pectoral fins and ventral region anterior to the vent. Immature males and females of all sizes had creamy or faint green coloration in the same regions. This compares with summer coloration when large (> 100 mm SL) *P. laeta* males have coloration which is indistinguishable from the year-round coloration of females and small males.

Timing of reproduction in the field

Pure white-coloured egg masses were observed at first sampling on 17 January in addition to creamy coloured masses noted on 29 January and 4 February 1980. Although no field observations were made earlier in 1980 to document when egg laying occurred, eggs were not found on 9 December 1980 or 9 January 1982, suggesting that mid-January is near the onset of egg laying. Of the seven egg masses found, four had two adults coiled around the egg mass and three had one adult. The change in colour of the eggs is presumed to be related to development, although progress was not followed to the eyed stage since observations were not possible between 4 February and 18 April due to insufficiently low tides. Local surface oceanographic conditions during January through April ranged from 4.0-10.0°C and salinity ranged from 8.0-27.5 ‰. No egg masses were seen on 18 April and presumably hatching had occurred.

Maturity and Fecundity

Large (1.18 ± 0.02 mm SE, N = 100), presumably mature eggs were found only in *P. laeta* over 100 mm SL. Fecundity increased from 621 eggs in a female of 101.4 mm SL to 1598 eggs in a 134.0 mm SL specimen (Figure 1). Only the left ovary was found to be developed in the specimens examined. Immature *P. laeta* (< 100 mm SL) contained eggs averaging 0.14 ± 0.01 mm SE (N = 40) in diameter.

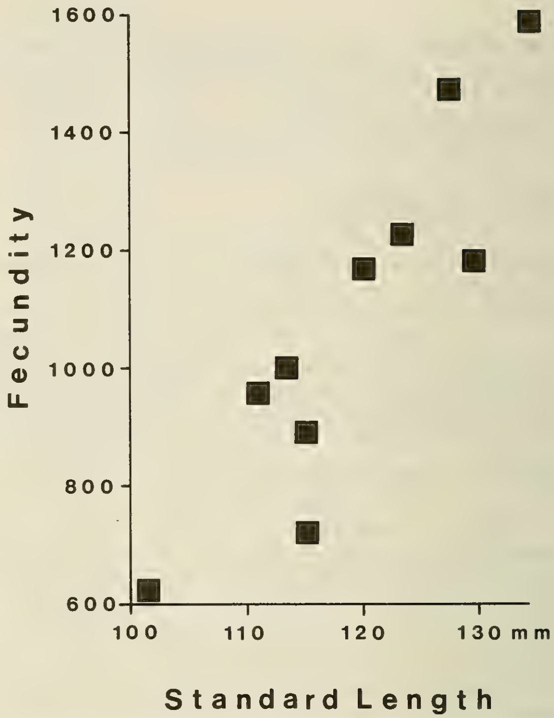

FIGURE 1. Fecundity of *P. laeta* collected at Patricia Bay, 17 January 1980.

Laboratory Spawning

All five pairs of *P. laeta* captured on 9 December 1980 spawned in the laboratory. Spawning was not observed but egg masses were first evident on 19 January (2 egg masses), 20 January (2 egg masses) and 23 January 1981 (1 egg mass). Eggs were white in colour and adhered to neighbouring eggs to form a single mass, but did not adhere to the cover or the substrate. In 83 observations, egg masses were tended by a single parent 23% of the time, by both parents 10% of the time, and were untended 67% of the time. Egg development proceeded with the eggs developing a creamy coloration similar to that noticed in the field, although later the egg masses broke into smaller clumps of eggs. Three egg masses hatched from 20-23 March, one mass may have been eaten, and one mass did not hatch. Larvae were positively phototactic and grew from an average of 8.5 mm to 10.0 mm in 24 days although they did not appear to feed on the plankton added to the aquaria and subsequently died.

Discussion

The breeding behaviour of *P. laeta* noted in this study is in general agreement with the parental care

activities noted for other *Pholis* (e.g. *P. gunnellus* by Gudger 1927; Qasim 1956; *P. ornata* by Fitch and Lavenberg 1975; *P. laeta* by Marliave and DeMartini 1977), although the implication of additional observations described here for *P. laeta* may be added.

Sexual dimorphism exhibited by the breeding coloration of male fish may be important in the recognition of the sexes and possibly in mate choice by *P. laeta*. As pairing occurred with usually only one breeding pair under a particular rock, perhaps the distinctiveness of the males is involved in the defense of the area from other males, although exclusion of other fish did not extend to juvenile *P. laeta* or to other species such as *Anoplarchus purpurescens*. It is not known whether pairing occurred before or after a breeding site was selected. Given the habitat selected for breeding, it is unlikely that strictly visual cues such as breeding coloration would be used once fish were in the dark "underneath rock" habitat.

The selection of habitat under rocks with apparently few openings to provide access suggests that it may be possible for *P. laeta* to force or dig their way into position, presumably by displacing some of the sandy substrate. This may be related to forcing entry into closed oyster shells by *P. gunnellus* which is suggested by Gudger (1927), who found a female guarding eggs in a shell that had both valves in place and closed.

The timing noted for *P. laeta* is similar to the winter breeding noted for *P. gunnellus* (Leim and Scott 1966), although egg laying in this Atlantic species may occur as early as November (Gudger 1927). The occurrence of spawning in the laboratory 41 days after the fish were collected as pairs from the field suggests that a considerable amount of time passes between pairing and spawning in *P. laeta*. This presumably serves to allow time for arousal and synchronization of breeding motor patterns so that successful mating occurs (Keenleyside 1979).

The similarity in shape of the rounded egg mass of *P. laeta* to the egg mass of *P. gunnellus* has been attributed to active rounding up of the eggs into a ball (Gudger 1927). Fecundity of *P. laeta* is similar to but slightly greater than that reported by Gudger for a 117 mm total length specimen (N = 686), although the relatively large eggs of *P. gunnellus* (approximately 2 mm: Leim and Scott 1966) may contribute to a smaller maximum number per female.

The reported egg guarding by two *P. laeta* (Marliave and DeMartini 1977) was confirmed in this study but this behaviour is not necessarily constant, given the incidence of single *P. laeta* with eggs in the wild.

Additionally, observations of fish in aquaria showed that the egg masses were not always guarded, although this may have been due to disturbance of the fish under the laboratory conditions. However, even with inconsistent guarding, hatching occurred in three egg masses and it is therefore unlikely that parents must provide consistently active care for the eggs. This successful hatching also suggests that water quality was adequate although the breaking of egg masses into clumps may have been due to necrosis of some eggs. No fanning of eggs was observed; this is consistent with reports for other pholidids. Guarding by *P. laeta* probably serves to protect egg masses from predation or from becoming dislodged into a more dangerous environment and, in this way, presumably contributes to the survival of the developing eggs. Hatching during March under laboratory conditions at 6°C is likely to be similar in timing to that at Patricia Bay where surface inshore temperatures from January to March 1980 averaged 5.8°C. Attempts to collect larvae from the field during the time of hatching were unsuccessful.

These observations of parental care, capture of apparently healthy spawned-out individuals, and analysis of population age structure showing mature fish at different ages (Hughes 1985) suggest that *P. laeta* probably reproduce annually after maturity. This may increase the chances of leaving surviving offspring, since the possibility of losing all potential offspring for an individual's life in one bad year is eliminated (Futuyma 1979).

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Notes

Wolves, *Canis lupus*, Killing Denning Black Bears, *Ursus americanus*, in the Riding Mountain National Park Area

Paul C. Paquet[1] and Ludwig N. Carbyn[2,3]

[1]Department of Zoology, University of Alberta, Edmonton, Alberta T6G 2E9
[2]Canadian Wildlife Service, Department of the Environment, 5320 - 122 Street, Edmonton, Alberta T6H 3S5
[3]Boreal Institute for Northern Studies, CW 401 Biological Sciences Building, The University of Alberta, Edmonton, Alberta T6G 2E9

Paquet, Paul C., and Ludwig N. Carbyn. 1986. Wolves, *Canis lupus*, killing denning Black Bears, *Ursus americanus*, in the Riding Mountain National Park area. Canadian Field-Naturalist 100(3): 371–372.

Three incidents of Wolves (*Canis lupus*) digging up, killing, and consuming denning Black Bears (*Ursus americanus*) were recorded.

Key Words: Wolf, *Canis lupus*, Black Bear, *Ursus americanus*, Polar Bear, *Ursus maritimus*, Manitoba.

Published accounts of Wolf (*Canis lupus*) and bear (*Ursus* spp.) interactions were recently reviewed (Rogers and Mech 1981; Ramsay and Stirling 1984). Included were records of Wolves in northern Minnesota killing and consuming a denning female Black Bear (*U. americanus*) and her newborn cubs, as well as Wolves in northern Manitoba killing Polar Bear (*U. maritimus*) cubs. In addition, Horejsi et al. (1984) described the killing of a female Black Bear by Wolves in northern Alberta. We report three additional observations of Wolves killing denning Black Bears in southwestern Manitoba. Ages of bears were determined by counting cementum annuli (Stoneberg and Jonkel 1966).

All observations were made during February 1984. Two of the three instances were observed in Riding Mountain National Park while ground-tracking Wolves. The third occurred about 50 km north of Riding Mountain in the Duck Mountain Provincial Forest (reported by Ed Coulson, Regional Fur director, Manitoba Department of Natural Resources). In all cases it was deduced from circumstantial evidence that the bears were killed by Wolves.

On 9 February, while tracking a single Coyote (*C. latrans*), we intercepted a heavily travelled Wolf trail. Tracks were less than two days old and diverged from a route commonly followed by Wolves and Coyotes throughout winter. The skull of a small bear, an intact front leg with attached scapula, and the partially consumed remains of the body were found less than 200 m north of the intersection. The sex of the animal was not determined. Hair was widely distributed throughout a 2 m radius of blood-stained snow. The carcass was less than 3 m from a southwest facing den, which consisted of a hollow depression less than 0.5 m deep, covered on one side by a horizontally inclined spruce (*Picea* sp.) about 0.5 m in diameter. From the distribution of plant material scattered near the den it was assumed that the remainder of the enclosure had been composed of bushes and dried grasses. The close proximity of the carcass to the den and blood patterns in the snow suggest the bear was killed in the den and dragged out. However, this could not be confirmed because the ground was heavily trampled. Snow thickness near the den ranged from 27 cm to 36 cm. The bear was estimated to be two years old. The Wolf pack apparently responsible for the killing was known to consist of at least ten members (7 adults, 3 pups). The total number involved, however, could not be estimated.

On 17 February 1984 we located a second Wolf-killed Black Bear approximately 2 km from a recently killed Elk (*Cervus elaphus*). The bear carcass was located about 18 m from the den and was not disarticulated, although most of the flesh had been consumed. The bear was estimated to be 11 years old. The den was 1.5 m deep and situated between two stumps and several dead falls. The entrance faced the northwest. Snow thickness near the den ranged from 21 cm to 37 cm, depending on proximity to the spruce canopy. Reconstruction through track and blood patterns suggested the Wolves attempted to dig the bear out of the den before it emerged. Large patches of sprayed blood covered the entrance to the den, indicating that the bear was wounded before moving away from the den. The bear was apparently killed

12 m from the den and dragged an additional 6 m. The Wolf pack responsible for the kill consisted of three animals. However, there was only evidence of two Wolves having participated in the kill. It is possible that the third set of tracks was not discernible but this is unlikely since we backtracked for 4 km without detecting additional tracks. Subsequent examination of the skull revealed that the bear had sometime earlier been shot in the face. The bullet entered below the left orbit, penetrated the palate, and exited through the angular process. We were unable to determine when the injury occurred or to what extent the bear was debilitated. We suspect the animal was wounded in the fall prior to denning, since bear hunting around Riding Mountain National Park is common at that time of year.

During the first week of February 1984, a trapper in the Duck Mountains observed five Wolves in close proximity to a bear carcass. He investigated the site and determined that the bear had been killed by Wolves. From the size of the skull he estimated the bear to be a young animal "not more than three years." The bear had a shallow den formed by a stump and a deadfall. The chamber was lined with dried plant material, some of which was distributed about the site. The Wolves dug three holes into the chamber, and tracks suggested that the bear emerged from the den and moved 15 m before being killed. The carcass was dragged another 30 m and with the exception of the head and shoulders was fully consumed. No snow thickness measurements were available and the skull was not recovered for ageing. Sex of the animal was undetermined.

The killing of Black Bears by Wolves is probably not a common phenomenon, and has not previously been noted in Riding Mountain National Park or the Duck Mountains. Analysis of over 2000 wolf scats collected between 1975 and 1984 in Riding Mountain National Park has yielded no evidence of bear remains. The reasons for the incidents in 1983 are unclear. However, unusually thin snow cover may have been a factor. The average annual snow depth is about 54 cm, and depths at kill sites in 1984 averaged about 30 cm. Wolves, however, should have no difficulty detecting denning bears except under the most severe winter conditions. Domestic dogs, for example, scenting upwind, are able to locate seal lairs at distances up to 1500 m (Smith and Stirling 1975), and we assume Wolves are equally capable. It is unclear, therefore, why several observations of bears killed by Wolves should be noted in a single year, and none in others.

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Occurrence of *Pennella filosa* (Copepoda: Pennellidae) on the Minke Whale, *Balaenoptera acutorostrata*, from the Bay of Fundy

W. E. HOGANS

Huntsman Marine Laboratory, St. Andrews, New Brunswick E0G 2X0

Hogans, W. E. 1986. Occurrence of *Pennella filosa* (Copepoda: Pennellidae) on the Minke Whale, *Balaenoptera acutorostrata*, from the Bay of Fundy. Canadian Field-Naturalist 100(3): 373–375.

Seventeen parasitic copepods of the family Pennellidae were found on a Minke Whale, *Balaenoptera acutorostrata*, captured at Blacks Harbour, New Brunswick. The characters of five specimens examined in detail agree with published descriptions of *Pennella filosa*. The characters of two previously described species of *Pennella* (*P. balaenopterae* and *P. antarctica*), also recorded from cetacea, fall within the variation of *P. filosa* and they both may be synonymous with it.

Key Words: *Pennella filosa*, parasitic copepods, *Balaenoptera acutorostrata*, Minke Whale, Bay of Fundy.

Pennellid copepods are common parasites of pelagic teleost fishes in the northwest Atlantic Ocean (Wilson 1932). The cephalothorax of adult females is embedded in the musculature of the host tissues, and the neck, trunk and abdomen protrude from the body surface. Morphology in the genus *Pennella* Oken, 1816, is variable and often dependent on, and influenced by, the site of attachment. A few species are occasionally found anchored in the blubber and musculature of whales. This paper describes the occurrence of one species, *Pennella filosa* L., on the Minke Whale, *Balaenoptera acutorostrata*, captured in the Bay of Fundy. *Pennella filosa* is previously unreported from this host.

A single Minke Whale (approximate length 7.5 m) was captured in a weir net set for Atlantic Herring (*Clupea harengus*) at Blacks Harbour, New Brunswick, on 10 July 1981. The whale was found dead in the net and removed to shallow water for examination. Five of 17 specimens of *Pennella* sp. present on the host were selected randomly and dissected from the body tissues. The entire parasite, as well as portions of the flesh surrounding the cephalothorax and neck, were fixed and stored whole in 10% buffered formalin. The cephalothorax was later dissected from fixed tissues to permit species identification. Specimens collected from the Minke Whale were found to be *P. filosa*.

Pennella filosa has been reported from several species of teleost fishes. It is most frequently documented from the Ocean Sunfish, *Mola mola*, Swordfish, *Xiphias gladius*, (Wilson 1917; Yamaguti 1963) and scrombrids of the genus *Thunnus* (cf. Kabata 1979). *Pennella filosa* has not previously been reported from any cetacean species. In Canadian waters, *P. filosa* has been reported only from the Swordfish (Wilson 1917; Tibbo et al. 1961).

The taxonomy of the genus *Pennella* is unreliable and in confusion (Kabata 1979). Many of the 31 documented species are incompletely known or poorly described. New species were often previously identified only on slight morphological variations which were caused by site of attachment in the host. *Pennella filosa* is one of the few species which has been adequately documented. A description of *P. filosa* based on five adult female specimens from the Minke Whale is as follows:

Cephalothorax sub-cylindrical with a flattened and truncate anterior extremity (Figure 1). Entire surface of anterior end covered with papillae of various sizes; those at outer margin approximately twice as large as those at center. Dorsal surface of cephalothorax with 2 – 4 conical papillae; twice again as large as those of the outer margin of the anterior end. First antennae 3-segmented, setose; second antennae 2-segmented and chelate, mouth parts indistinct. Junction of

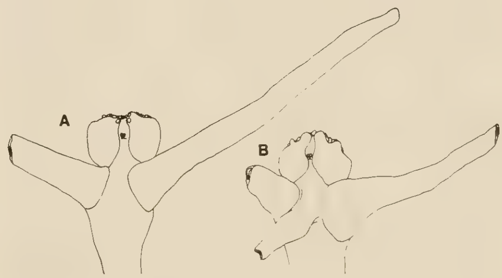

FIGURE 1. Dorsal view of the anterior ends of *Pennella filosa*. A. specimen without dorsal horn. B. specimen with dorsal horn.

cephalothorax and neck indistinguishable, with two unbranched lateral horns protruding from the area of the dorsal surface. A third dorsal horn, one-half the length of the others, is occasionally present. Neck one-half as long as the trunk, which is transversely ridged. Trunk narrowing at junction with abdomen. Abdomen sub-cylindrical, possessing many large plumes with secondary and tertiary plumules which originate from the ventral surface. Egg strings filiform, about one and one half length of entire parasite. Eggs uniseriate. Mean total length of specimens 190.0 mm (range 159 to 212 mm).

The specimens examined during the present study agree well with adult female *P. filosa* described by Kabata (1979) and Wilson (1917). These authors mention the occasional absence of the smaller dorsal horn. The cephalothorax of four specimens recovered from the blubber showed prominent dorsal horns. The remaining specimen had completely perforated the blubber and was lodged in hard muscle tissue. The structure of the cephalothorax may be related to site of attachment. Soft and easily penetrated tissue, such as blubber, may necessitate the growth of the dorsal horn to afford a greater hold in the host. In hard, muscular tissue, the lateral horns alone may provide a sufficient hold.

Lateral horn length in all specimens was variable and did not appear to be influenced by site of attachment. Specimens recovered from the hard muscle tissue and the blubber showed both long and short lateral horns. Lengths of lateral horns are variable in *P. filosa* (cf. Kabata 1979). Wilson (1917) describes *P. filosa* as having an anterior end completely covered by papillae; specimens from this study are similar.

Five species of pennellid copepods have been reported from whales. They are *P. antarctica*, on *Balaenoptera borealis* (cf. Wilson 1920; Heegaard 1934), *P. anthonyi* on *B. physalus* (cf. Quidor 1913), *P. balaenoptera* on *Balaenoptera* sp. (Koren and Danielssen 1877; Anthony and Calvert 1905; Quider 1913; Brian 1944), *P. cetti* on *B. physalus* (cf. Quidor 1913) and *P. charchoti* on *Balaenoptera* sp. (Quidor 1913). Only one species, *P. balaenopterae*, has been reported from the northwest Atlantic Ocean (Koren and Danielssen 1877). The remaining species (*P. antarctica, P. anthonyi, P. cetti* and *P. charchoti*) are reported from Antarctic waters and the coast of Georgia, U.S.A. (*P. antarctica*). The Minke Whale is recorded as a seasonal resident of Atlantic Canadian coastal waters. Its distribution extends from the Ungava Bay region (summer) to Florida in winter (Sargeant 1961). This limited range may exclude them from infection with those species other than *P. antarctica* and *P. balaenopterae*.

Leigh-Sharpe (1928) documents *P. balaenoptera* as a valid species, distinct from *P. filosa*, based on the length ratio of neck to trunk. This is the only apparent difference between the species; the remaining structures, especially those of the cephalothorax, are similar in both species. Kabata (1979) records the length ratio of neck to trunk as influenced by the site of attachment and depth of penetration and therefore unsuitable for use as a taxonomic character. Wilson (1917) described *P. antarctica* as a distinct species based on the appearance of the neck (long and slender) and angle of the lateral horns (inclined forward). The remaining structures of *P. antarctica* are similar to those of *P. filosa*. It is possible that the taxonomic features of *P. balaenoptera* and *P. antarctica* may fall into the wide range of morphological variability exhibited by *P. filosa*, and that all three species are synonymous.

Specimens of *Pennella filosa* recovered from the Minke Whale are deposited in the Atlantic Reference Collection at the Biological Station, Department of Fisheries and Oceans, St. Andrews, catalogue number 509-84.

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Two Partial Albino Eastern Redback Salamanders, *Plethodon cinereus*, in Nova Scotia

JOHN GILHEN

Nova Scotia Museum, Halifax, Nova Scotia B3H 3A6

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Two Eastern Redback Salamanders taken in Nova Scotia at Poison Lake, Cumberland County (45°33′N, 63°56′W) and First Lake, Halifax County (44°46′N, 63°40′W) are partial albinos of the erythristic phase and the redback phase, respectively. These are the only two partial albino *Plethodon cinereus* recorded in Canadian populations.

Key Words: Partial albino, Eastern Redback Salamander, *Plethodon cinereus*, erythristic phase, redback phase, Nova Scotia.

Although albinism is widely reported in living organisms, there is some value in briefly placing geographic occurrences in the published record where they will be readily accessible to future researchers. Here, I document the second record for a partial albino Redback Salamander, *Plethodon cinereus* (Green), from Canada, and give additional data on the first (Gilhen 1984). Dyrkacz (1981) reported one albino of the species from Maryland.

The Eastern Redback Salamander is the most common salamander in Nova Scotia. Two colour phases termed "redback" and "leadback" are widespread and an erythristic phase is more restricted (Gilhen 1984). Only two partial albinos have been found in over two thousand *Plethodon cinereus* that I have seen during active field work throughout Nova Scotia. One (Gilhen 1984) is an adult female 50 mm in body length (snout to posterior angle of vent) and 91 mm in total length, found under a rock in mature deciduous forest near Poison Lake, Cumberland County (45°33′N, 63°56′W) by me on 1 June 1973. The other, an adult male 35 mm body length and 63 mm total length, was found under a block of firewood on a lawn close to mixed forest near First Lake, Halifax County (44°46′N, 63°40′W), by Mark Porter on 24 June 1984 and was donated by Craig Hursham.

The Poison Lake specimen (NSM973-634-1) was like the all-red (erythristic) phase except that the area of the back and sides, instead of being red, varied from pinkish-white to milky-white. There were black blotches on the tail and some smaller black spots on the trunk. The First Lake individual (NSM984-108-1), however, resembled the redback phase: the dorsal stripe was purplish-white anteriorly and pinkish-white with fine circular red lines posteriorly. The sides of the trunk were pinkish-white speckled with small dark grey dots. The tail was milky white speckled with small dark grey dots. Both specimens had black eyes and the skin on the underside was transparent. Colour photos are on file at the Nova Scotia Museum.

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A Hawk's-beard, *Crepis pulchra*, Adventive in Ontario

WILLIAM J. CODY[1] and WILLIAM L. PUTMAN[2]

[1]Biosystematics Research Centre, Agriculture Canada, Ottawa, Ontario K1A 0C6
[2]114 Livingston Ave., Grimsby, Ontario L3M 1L6

Cody, William J., and William L. Putman. 1986. A hawk's-beard, *Crepis pulchra*, adventive in Ontario. Canadian Field-Naturalist 100(3): 376–377.

Crepis pulchra, a hawk's-beard, is reported as adventive in Ontario. The plant is described briefly and diagnostic characters to separate the genus *Crepis* from the somewhat similar genus *Hieracium* (hawkweeds), and *C. pulchra* from the introduced species in Ontario, *C. capillaris* and *C. tectorum*, are presented.

Key Words: *Crepis pulchra*, hawk's-beard, Ontario, adventive.

In 1972 Putman discovered a species of Compositae that was unknown to him along a Canadian National Railway allowance near Grimsby, Ontario (43° 12′N, 79° 34′W). This was initially identified as a species of *Hieracium* (hawkweed) but the identification was subsequently revised to *Crepis pulchra* (hawk's-beard), a native of southern Europe. Only a single plant was found at this locality. In 1975 Putman found a colony of about 50 plants along the same railway allowance about 15 km distant from the first site. Data for these collections are:

ONTARIO: Lincoln Co., North Grimsby Twp., railway near Oakes Rd., *W. L. Putman 104*, 4 July 1972; Wentworth Co., Saltfleet Twp., railway embankment between Kelson and Fifty roads, *W. L. Putman 161*, 26 June 1975 (DAO) [acronyms follow Holmgren et al. 1981], (Figure 1).

The species has not previously been reported from Ontario or the other Canadian provinces.

In 1979 Cody contacted Putman to suggest that the progress of the introduction be monitored. Putman visited the area in August of 1982 but could not distinguish any *Crepis* among the dead hawkweed stems and other vegetation. On 30 June 1983, Putman again visited the site. At this time plants, if present, should have been tall and in full bloom. None were found, and, although raspberry (*Rubus* sp.) and goldenrod (*Solidago* sp.) had spread somewhat about the site, it seemed scarcely possible that they would have completely crowded out the *Crepis*. On 26 June 1984 Putman visited the site again but no plants were found.

Crepis pulchra is described by Fernald (1950) as a biennial. Gleason (1958), Gleason and Cronquist (1963), Tutin et al. (1976), and Cronquist (1980) report it as an annual. *C. pulchra* has a fibrous taproot. It is an annual or may be a winter annual.

The stems of *Crepis pulchra*, which sometimes branch from the base and may grow as tall as 100 cm, bear spreading glandular hairs below and are glabrous above. The leaves bear short glandular and longer eglandular hairs on both surfaces; the basal leaves are 15 or more cm long, rosulate, oblanceolate, acute to obtuse, narrowed at the base, denticulate to runcinate-dentate or pinnatifid, with triangular acute lobes; the lower cauline leaves are similar to the basal, but lanceolate and less divided; upper cauline leaves

FIGURE 1. *Crepis pulchra, W. L. Putman, 161* (DAO) collected at Saltfleet Twp., Wentworth Co., Ont.

are linear or bract-like. The inflorescence is a compound corymb. The glabrous involucre is 8–12 mm high; the inner bracts generally have a raised and thickened midrib; the outer bracts are very short. The yellow flowers are all ligulate. The achenes, which measure 4–6 mm in length, are tapered toward the tip but not beaked, stramineous or pale greenish and are 10–12 ribbed; the outer ones are scabrous-hirtellous.

The genus *Crepis* may be separated from the somewhat similar genus *Hieracium* as follows:

Crepis

— achenes somewhat attenuate above
— phyllary bracts usually thickened at base and midrib
— pappus white, not brittle
— flower heads numerous in a compound corymb
— plants without stellate hairs

Hieracium

— achenes obconical
— phyllary bracts not thickened
— pappus sordid or tawny, brittle
— flower heads few in an open panicle
— usually at least some part of the plant with stellate hairs

Two other introduced species of hawk's-beard are known to occur in Ontario: *Crepis tectorum* is a fairly common weed, whereas *C. capillaris* has been found much less frequently. From *C. pulchra* the former may be distinguished among other characters by its dark purplish-brown achenes and the tomentose-puberulent and sometimes also glandular-hispid inner bracts that are strigose or puberulent on the inner surface; the latter may be distinguished from *C. pulchra* by its shorter (5–8 mm long) involucre and shorter (1.5–2.5 mm long) achenes.

Fernald (1950) gave the habitat and range of *C. pulchra* as "Roadsides and wooded slopes, local, Va. and Ind. (Natzd. from Eu)." Gleason (1958) included Ohio in the North American range and suggested that the species might be expected elsewhere. Tutin et al. (1976) gave the European range as "S. Europe, extending northwards to N. France and S.E. Czechoslovakia; casual further north." This last comment seems to indicate that perhaps the more rigorous climate northward is a limiting factor. If this is true, then the severe winters of 1980–81 and 1981–82 in southern Ontario may have eliminated the species at our site. Dorph-Petersen (1924) has reported that the seeds of *C. tectorum* germinate in the spring. Thus they are short-lived. If the seeds of *C. pulchra* are equally short-lived, then it is also possible that the disappearance might be the result of spraying of a chemical weed killer along the railway right-of-way. *Crepis pulchra* should, however, be watched for elsewhere in southern Ontario and perhaps in coastal southern British Columbia and the Maritime Provinces where it might again be introduced and become established.

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Productivity and Mortality Rates of Southern Ontario Pond- and Stream-Dwelling Muskrat, *Ondatra zibethicus*, Populations

GILBERT PROULX[1] and BRUCE M. L. BUCKLAND[2]

[1]34 Donjeux, Lorraine, Quebec, J6Z 3C5
Present address: Alberta Environmental Centre, Bag 4000, Vegreville, Alberta, T0B 4L0
[2]Ontario Ministry of Natural Resources, Box 2186, Cambridge, Ontario, N3C 2W1

Proulx, Gilbert, and Bruce M. L. Buckland. 1986. Productivity and mortality rates of southern Ontario pond- and stream-dwelling Muskrat, *Ondatra zibethicus*, populations. Canadian Field-Naturalist 100(3): 378–380.

In southern Ontario, a lack of data on productivity and mortality for Muskrats (*Ondatra zibethicus*) hinders the management of pond, ditch, creek and river populations. The analysis of Muskrats captured from 16 October to 17 November 1983 in Cambridge District of the Ontario Ministry of Natural Resources indicated that female Muskrats produced an average of two litters of 6.0 young/litter in creeks, 6.5 young/litter in ditches and rivers, and 6.7 young/litter in ponds. River populations had the lowest summer juvenile mortality rate (38.5%) followed by pond (43.3%), ditch (47.7%), and creek (57.5%) populations. These mortality rates were higher than those reported from southern Ontario marsh populations. Pond, ditch, creek, and river Muskrat populations differ sufficiently from each other, and from Muskrat populations studied in the past, to warrant more site-specific field studies.

Key Words: Muskrat, *Ondatra zibethicus*, productivity, mortality, ponds, streams, Ontario.

In southern Ontario, Muskrat, *Ondatra zibethicus*, populations have been harvested for centuries (Innis 1956). Today, our understanding of marsh populations is well advanced (Wragg 1953; Proulx and Gilbert 1983; Proulx et al. 1983*, 1984**) but our knowledge of Muskrat populations inhabiting ponds and streams, where most of the trapping occurs, is very incomplete. To our knowledge, no study has been carried out on the dynamics of those populations in southern Ontario. The average productivity per female and the survival rate of the animals are two essential parameters in the determination of Muskrat population trends (Proulx and Gilbert 1984) and in the establishment of a sound management program (Proulx 1984). The aim of this study was to determine the number of young being conceived and surviving until the fall trapping season in ponds, ditches, creeks, and rivers included in the Cambridge District of the Ontario Ministry of Natural Resources.

Muskrat carcasses were provided by nine trappers from 16 October to 17 November 1983. Each carcass was wrapped individually in a plastic bag, and a label with the trapper's initials and date of capture was attached to a hind leg of the carcass. Information relative to the capture sites was also obtained from the trappers. The Muskrat populations were grouped together according to their habitat type. The river population consisted of four population samples: two from Grand River, one from Conestogo River, and one made up of Muskrats captured in both rivers. Because the Muskrat origins of the fourth river sample could not be differentiated between the two rivers, this sample was not used in the comparison of the Conestogo River and Grand River population samples. Muskrats were aged according to Sather (1954) and sexed. Mean litter size and number of litters per breeding female were estimated using placental scars. These values, associated with the ratio of juveniles per reproductive female, provided an estimation of summer juvenile mortality (Proulx 1981). Embryo resorption in Muskrat is rare (Perry 1981) and was not taken into account.

Female Muskrats produced an average of two litters of 6.0 young/litter in creeks, 6.5 young/litter in ditches and rivers, and 6.7 young/litter in ponds (Table 1). No significant difference ($p > 0.05$) existed between the females' productivity. The greatest variation in productivity was found in creek and pond populations (Table 1). The river population had the lowest summer juvenile mortality rate (38.5%), followed by the pond (43.3%), ditch (47.7%) and creek (57.5%) populations. No significant correlation ($r = 0.303$, $p > 0.05$) existed between the average number of placental scars/female and the fall number of juveniles/breeding female of each trapper's sample.

The average productivity of Grand River and Conestogo River Muskrats was 12.4 (± 2.6) and 13.8

*Proulx, G., N. L. Tilt, and B. M. L. Buckland. 1983. Muskrat harvest rate studies. Progress Report #1. Ontario Ministry of Natural Resources, Cambridge, District. Unpublished report. 12 pp.

**Proulx G., N. L. Tilt, and B. M. L. Buckland. 1984. Muskrat harvest rate studies. Progress Report #2. Ontario Ministry of Natural Resources, Cambridge District. Unpublished report. 19 pp.

TABLE 1. Characteristics of southern Ontario pond, ditch, creek and river Muskrat populations — fall 1983.

	Habitats					
	Pond	Ditch	Creek	River (Composite)*	Grand River	Conestogo River
POPULATION CHARACTERISTICS						
Number of samples	2	2	3	4	2	1
Number of breeding females	5	5	5	32	10	11
Average Productivity	13.4	13.0	12.0	13.0	12.4	13.8
Standard Deviation	4.8	3.1	3.9	2.8	2.6	2.6
Productivity Range	6–18	9–17	4–16	8–19	8–14	9–18
Coefficient of variation	35.8%	23.8%	32.6%	21.8%	21.2%	19.1%
Juveniles/Breeding Female	7.6	6.8	5.1	8.0	5.6	8.7
Summer Juvenile Mortality Rate	43.3%	47.7%	57.5%	38.5%	54.8%	37.0%

*This population comprises the Grand River samples, the Conestogo one, and a fourth sample made up of Muskrats captured in both rivers.

(± 2.6), respectively. This difference was not significant ($t = 1.215$, $p > 0.05$). The summer juvenile mortality rate was markedly lower in Conestogo River (37%) than in Grand River (54.8%).

In the past, the management of pond, ditch, creek and river populations was based on data recorded for populations inhabiting similar ecosystems farther south or for populations in marshes. The present findings show that the pond and stream females' productivity was similar to that of southern Ontario marsh Muskrats studied by Wragg (1953: 2 litters of 6.1 young), Proulx and Gilbert (1983: 2 litters of 6.3 young), and Proulx et al. (1983: 2 litters of 6 young; 1984: 2 litters of 6.6 young). However, the females in the present study were more productive than those reported by Shanks and Arthur (1952), Arata (1959) and Erickson (1963) for ponds, and by Schacher and Pelton (1975) for streams.

In the present study, the mortality rates ranged from 38.5 to 57.5% and were greater than those reported by Proulx and Gilbert (1983, 34.6%) and Proulx et al. (1983, 24.8%; 1984, 25.8%) for marsh populations, and Erickson (1963, 36.6%) for pond populations. They were, however, lower than those reported by Baumgartner and Bellrose (1943, 70%) for mixed population types, Alexander (1951, 62%), Chamberlain (1951, 61–73%) and Dorney and Rusch (1953, 67%) for marsh populations, and Stewart and Bider (1974, 62.1%) for ditch populations. The present study shows that the southern Ontario pond- and stream-dwelling Muskrat populations differ from populations studied elsewhere in similar environments and from marsh dwelling populations. Therefore, one should be cautious about applying the results of past studies to the management of the Muskrat populations investigated here.

Proulx and Gilbert (1983) have shown that changes in water levels and in floristic composition may have a major impact on the productivity and survival of Muskrats. The present study showed that more juveniles died over summer in ponds and ditches than in rivers, and that the creek population had the lowest productivity level and summer juvenile survival rate. Ponds, ditches and creeks are more unstable environments than rivers (Errington 1937), as their water levels are very variable and dependent upon the amount of precipitation (Proulx 1981). Habitat differences may also explain differences found between the Conestogo River and Grand River populations. On the average, the Conestogo River females produced 1.4 more Muskrats than the Grand River ones and 3.4 more juveniles/female survived over the summer months in Conestogo River. These differences could be biologically significant on a long-term basis if this situation persists (Proulx and Gilbert 1983), and different harvest management programs should be established in each area.

As environmental conditions may affect the number of young born and surviving over the summer months (Proulx and Gilbert 1983), more site-specific studies should be conducted to determine how Muskrat environmental conditions vary among habitat types. Such studies could have major implications for the southern Ontario trapping regulations where the majority of trapping occurs in rivers, ponds and creeks rather than in marshes.

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Wild Bergamot, *Monarda fistulosa* (Lamiaceae), New to the Northwest Territories

GERALD B. STRALEY

The University of British Columbia Botanical Garden, 6501 Northwest Marine Drive, Vancouver, British Columbia V6T 1W5

Straley, Gerald B. 1986. Wild Bergamot, *Monarda fistulosa*, (Lamiaceae), new to the Northwest Territories. Canadian Field-Naturalist 100(3): 380–381.

Monarda fistulosa L. is reported from the Northwest Territories for the first time, disjunct some 1300 km from the nearest known locality in Alberta.

Key Words: Wild Bergamot, *Monarda fistulosa*, Northwest Territories.

While going through a backlog of unidentified specimens in the herbarium at The University of British Columbia (UBC), the author found a collection of the Wild Bergamot, *Monarda fistulosa* L., from the Mackenzie Delta of the Northwest Territories. The collection was made by Ross Shotton, a graduate student at UBC, on a rocky exposed northwest-facing river bank, 3.5 miles up the

Sainville River from Arctic Red River (133°50′W, 66°30′N) on 23 June 1972. This appears to be the first record of the species from the Northwest Territories and a range extension of some 1300 km northwest of its previously known range. Porsild and Cody (1980) do not record the species from the continental Northwest Territories. It is known from the Peace River area of British Columbia and Alberta (56°N latitude) and Raup (1935) cites a collection from the Peace Point prairie in Wood Buffalo National Park in northeastern Alberta (59°N latitude).

The specimen is typical of var. *menthifolia* (Grah.) Fern. or the species *Monarda menthifolia* Grah., if recognition is given at the species level. Plants are relatively unbranched, with single heads and nearly sessile cauline leaves. The plants are slightly shorter and the heads are slightly smaller than typical *M. fistulosa* from further south.

Specimens are deposited in UBC and CAN.

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First Three Records of the Wreckfish, *Polyprion americanus*, for Nova Scotia

JOHN GILHEN

Nova Scotia Museum, 1747 Summer Street, Halifax, Nova Scotia B3H 3A6

Gilhen, John. 1986. First three records of the Wreckfish, *Polyprion americanus*, for Nova Scotia. Canadian Field-Naturalist 100(3): 381–382.

Three records for Wreckfish, *Polyprion americanus*, are the first for Nova Scotia. One specimen was captured on 1 August 1984, 65 km south of Owls Head, Halifax County, one from 32 km south of Owls Head in 1979, and one from off Shelburne County in 1983.

Key Words: Wreckfish, *Polyprion americanus*, new records, Nova Scotia.

The Wreckfish, *Polyprion americanus* (Schneider 1801), family Percichthyidae, has been previously recorded for Canada twice on the Grand Bank (Leim and Scott 1966). It is found on both sides of the Atlantic Ocean (Hardy 1978). The first Nova Scotia records are reported here.

One specimen was captured on 1 August 1984 by Frank Harvey Stevens using a gaff. It was swimming near the surface around the buoy of a gill net, 65 km south of Owls Head, Halifax County, Nova Scotia (44°24′03″N, 62°34′01″W) (Figure 1). Byron Hutt subsequently advised me that he had captured a Wreckfish about 32 km south of Owls Head in September 1979 and provided a photograph which verified the identity. Unfortunately the specimen was not kept. Daryl Lyon, fisheries officer, Lockeport, contributed a third record, and the specimen which he had kept frozen since the day of capture. The only data available, however, is that it was captured off Shelburne County during the summer of 1983.

The 1984 Owls Head specimen [NSM984-401-1(1)] and the Shelburne County specimen (NSM985-86-1(1)) are preserved in the Nova Scotia Museum. Length measurements in millimeters, fin spine and ray counts and vertebrae number for the Owls Head specimen are followed in parentheses by the data for the Shelburne County specimen. Length: total, 491(550); standard, 416(480); body, 280(325); head, 149(180); eye diameter, 30(31). Fins: dorsal, XI, 12(X,11); anal, III, 9 (II,10). Vertebrae: 13 + 13 (13 + 13). The Shelburne County specimen is unusual in having a low dorsal spine count, only two spines preceding the anal fin and a high anal ray count (Hardy 1978).

Acknowledgments

I want to thank Mr. Frank Harvey Stevens for donating the Owls Head Wreckfish to the Nova Scotia Museum and his wife Constance Ellen Stevens for advising me of its capture. Byron Hutt provided

FIGURE 1. Wreckfish, *Polyprion americanus*, captured 65 km south of Owls Head, Nova Scotia on 1 August 1984.

information and a photograph of a Wreckfish he captured. Darly Lyon donated the Shelburne County specimen. Darlene Devison took the radiograph and Ron Merrick photographed the Wreckfish in Figure 1. Doris Cruikshank typed the manuscript.

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Observations on Norway Rats, *Rattus norvegicus*, in Kodiak, Alaska

GLENN E. HAAS,[1] NIXON WILSON,[2] and HAROLD D. BRIGHTON[3]

[1]State of Alaska Department of Health and Social Services, Anchorage, Alaska.
Present address: 557 California Street, No. 7, Boulder City, Nevada 89005
[2]Department of Biology, University of Northern Iowa, Cedar Falls, Iowa 50614
[3]State of Alaska Department of Health and Social Services, Kodiak, Alaska.
Present address: 1320 Madsen Avenue, Kodiak, Alaska 99615

Haas, Glenn E., Nixon Wilson, and Harold D. Brighton. 1986. Observations on Norway Rats, *Rattus norvegicus*, in Kodiak, Alaska. Canadian Field-Naturalist 100(3): 383–385.

Trapping in the city of Kodiak and vicinity in January and September 1974 yielded 59 Norway Rats (*Rattus norvegicus*). Immature rats were collected in both months; only one of ten adult females was pregnant in January and none of eight in September. Most rats were in the city, and no wild populations were found. Fifty-eight of the rats were in good physical condition; ectoparasites were not abundant.

Key Words: Norway Rats, *Rattus norvegicus*, ecology, biology, reproduction, body weight, body size, trapping, ectoparasites, Alaska.

An increasing number of complaints since 1971 of Norway Rats, *Rattus norvegicus*, in the city of Kodiak and vicinity prompted environmental surveys in January and September 1974 with the ultimate purpose of improving the local rat control program. The first appearance of rats in the Kodiak Archipelago is unrecorded, but Clark (1958), Manville and Young (1965), and others have reported their presence in more recent times. Probably, as Rausch (1969) stated, the rat became established soon after the arrival of Europeans. Kodiak (57°47′N, 152°24′W), founded in 1792 and the capital of Alaska until 1804, grew into an important fishing port on the northeast coast of Kodiak Island, the largest of the Archipelago (over 9360 km^2). By 1973 the greater Kodiak area had a population of 9049 (Alaska Department of Economic Development 1973), and in 1974 there were 14 seafood processing plants along the shore in and near the city.

Materials and Methods

In January, large snap traps were baited with fresh coconut and set in 22 localities in the city, based on records of complaints and on visual detection of rat sign. Stations were both inland and along the shore, and included seafood processing plants, the small boat harbor, and business and residential areas. Traps were set outside the city at the refuse dump and at a remote wild area on Monashka Bay near the mouth of Pillar Creek, 2.6 km from the city. Snap-trapped rats were examined for injuries and ectoparasites and were weighed on a triple-beam balance. Standard body measurements were recorded before dissections were made.

In September, large National live traps baited with fresh coconut were set at only one locality, a sloping, open brushy area beside the seafood processing plants at the base of Pillar Mountain, where a high abundance of rats had been noted in January. Live-trapped rats were individually anaesthetized with ether, examined, and weighed. Body measurements were not taken nor were dissections made.

Results and Discussion

The January collection consisted of 30 Norway Rats from and near the city of Kodiak. No rats were trapped in wild terrain at Monashka Bay. Wild populations of Norway Rats occur along the shore lines of Aleutian islands such as Adak (Schiller 1952), Amchitka (Brechbill 1977), and Rat (Murie 1959). In September 29 rats were live-trapped near seafood processing plants in Kodiak. Trapping records of the two surveys are given in Table 1.

Rats are grouped by age and sex in Table 2. Of the 59 specimens, 34 (58 percent) were adults, 25 (42 percent) were immature individuals, 26 (44 percent) were males, and 33 (56 percent) were females. Age of the September catch was based mainly on body weights (Table 2), since specimens were not dissected. In January, all adults weighing over 200 g had heavy bodies with considerable amounts of fat deposited in the body cavity, and immature rats had slender bodies. These body types are normal according to Calhoun (1963) when rats have access to more food than required to fulfil demands for optimum growth.

One of ten adult females collected in January had two embryos and another was in pre-estrous. The embryos measured 30 and 33 mm, and birth would have occurred on about 17 January. This female probably had access to buildings. The female in pre-

TABLE 1. Records of *Rattus norvegicus* trapped at Kodiak, Alaska, January and September 1974.

Date	Traps Set	Traps Sprung or Missing	Rats Trapped	Adjusted % Trap Success
January (Various localities; snap traps)				
9	10	2	2	25
10	24	7	5	29
11	23	4	4	21
12	17	1	1	6
13	27	4	5	22
14	27	6	4	19
15	32	13	7	37
16	2*	2*	0	—
17	6*	0*	2	33
Total or Average	168	39	30	23
September (Near seafood processing plants; live traps)				
19	20	4	10	63
21	15	0	10	67
22	10	2	5	63
23	7	0	4	57
Total or Average	52	6	29	63

*Excludes traps buried by snow.

estrous was trapped in a converted garage. The pregnant female had placental scars, but the pre-estrous one had none, suggesting no previous breeding. In September, three of eight adult females examined externally had enlarged nipples indicating current or recent lactation. Some breeding in January was expected because the climate is relatively mild and some rats live entirely or partly indoors. In the more severe climate of Nome, Schiller (1956) found no pregnant rats in January. On Adak in May he found 17 percent of mature females pregnant with 5 to 19 embryos (average 12) (Schiller 1952).

Physical injuries were observed on one rat. A female trapped in January had all its toes missing. Ectoparasites were not abundant. Six northern rat fleas (*Nosopsyllus fasciatus*), one spined rat louse egg (*Polyplax spinulosa*), and three mites (*Androlaelaps fahrenholzi*) were collected from the rats in January; 15 northern rat fleas and four spined rat louse adults were collected in September.

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TABLE 2. Mean body weights and measurements ± standard error (range in parentheses) of *Rattus norvegicus* trapped in the city of Kodiak and vicinity, Alaska, January and September 1974. N denotes sample size.

Age and Sex	N	Body Weight (g)	Standard Measurements (mm) Total Length	Tail	Hind Foot	Ear
			January			
Adult males	4	309 ± 28.7 (248–371)	375 ± 9.3 (350–392)	165 ± 3.4 (159–172)	40 ± 1.3 (40–46)	19 ± 0.8 (17–21)
Immature males	8	78 ± 9.2 (55–139)	232 ± 11.2 (194–296)	100 ± 7.1 (71–131)	34 ± 1.1 (29–39)	16 ± 0.2 (16–17)
Adult females	10	233 ± 24.2 (140–372)	352 ± 9.9 (311–420)	163 ± 5.1 (146–194)	40 ± 0.6 (38–44)	18 ± 0.5 (16–20)
Immature females	8	72 ± 8.1 (57–127)	234 ± 10.4 (207–300)	100 ± 6.7 (74–133)	32 ± 0.8 (28–35)	16 ± 0.3 (15–17)
Total	30					
			September			
Adult males	12	265 ± 16.4 (196–373)				
Immature males	2	125 ± 4.5 (120–129)				
Adult females	8	257 ± 23.0 (187–402)		(not taken)		
Immature females	7	92 ± 3.7 (79–105)				
Total	29					

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Salix raupii, Raup's Willow, New to the Flora of Alberta and the Northwest Territories

GEORGE W. ARGUS

Botany Division, National Museum of Natural Sciences, Ottawa, Ontario K1A 0M8

Argus, George W. 1986. *Salix raupii*, Raup's Willow, new to the flora of Alberta and the Northwest Territories. Canadian Field-Naturalist 100(3): 386–388.

Salix raupii Argus, previously known only from British Columbia, has been discovered in Alberta and the Northwest Territories. Its description has been amplified and the way it may be recognized from similar *Salix* species is discussed.

Key Words: *Salix raupii*, Raup's Willow, taxonomy, phytogeography, Alberta, Northwest Territories.

Salix raupii is a little known western Canadian endemic described in 1974 on the basis of five specimens from British Columbia (Argus 1974). Since that time it has been found in Alberta and the Northwest Territories and at a new locality in British Columbia (Figure 1). The purpose of this paper is to report these new finds, to amplify the description of *S. raupii*, and to discuss how it can be distinguished from similar *Salix* in the floras of Alberta (Moss 1983), Alaska and Yukon (Hultén 1968; Viereck and Little 1972; Argus 1973; Welsh 1974), and the continental Northwest Territories (Porsild and Cody 1980). It is hoped that by calling this species to the attention of western botanists and by making it easier to identify using existing keys, its distribution and taxonomy will become more fully known.

Raup's Willow, *Salix raupii* Argus (1974): Amplified Description

Shrubs 1.2-1.8 m tall; branches greyish-brown, epidermis on 3-year-old shoots prominently exfoliating; branchlets glabrous, glossy and chestnut brown. Leaves elliptical or narrowly so, rarely somewhat obovate, the largest mature leaves 3.2-5.8 cm long, 1.2-1.9 cm wide, and 2-3.3 times as long as wide, apex obtuse or acute; base rounded to acute; margins lacking prominent teeth, if present then glandular crenate (the lowermost leaves sometimes glandular-serrulate), and slightly revolute; immature leaves glabrous and greenish, sometimes ciliate; lower side of mature leaves plane and prominently glaucous; petioles 5-9 mm long, yellowish and glabrous; stipules linear to narrowly elliptical, 1-3 mm long. Aments coetaneous. Staminate aments 2.5-3.5 cm long, on flowering branchlets 0.8-1.2 cm long; stamens two, filaments glabrous, about 0.5-0.8 mm long; dry anthers 0.4-0.7 mm long; nectaries two, abaxial and adaxial, each with one to three lobes about 0.8 mm long; bracts elliptical, apex rounded, 1.6-2.5 mm long, pale lemon-yellow to bicolored and then pink or brownish at apex, glabrous on outer side, sometimes sparsely sericeous on inner side. Pistillate aments 2-3.5 cm long, flowering branchlets 0.5-1.8 cm long; pistils greenish-brown, glabrous or with two longitudinal bands of short, fine hairs, capsules 4.4-8 mm long, ovules 12-14; styles 0.6-0.8 mm long, stigmas 0.4 mm long; stipes 0.4-1.2 mm long, pubescent; nectaries one, adaxial, simple or two-forked, 0.6-0.8 mm long, equalling or slightly longer than stipes.

New records for *Salix raupii*

ALBERTA:

1. Nose Mt. north flank of mountain just south of trail leading to the headwaters of Muddy Creek, 54°30′N, 119°32′W (approximate). *John Corbin*

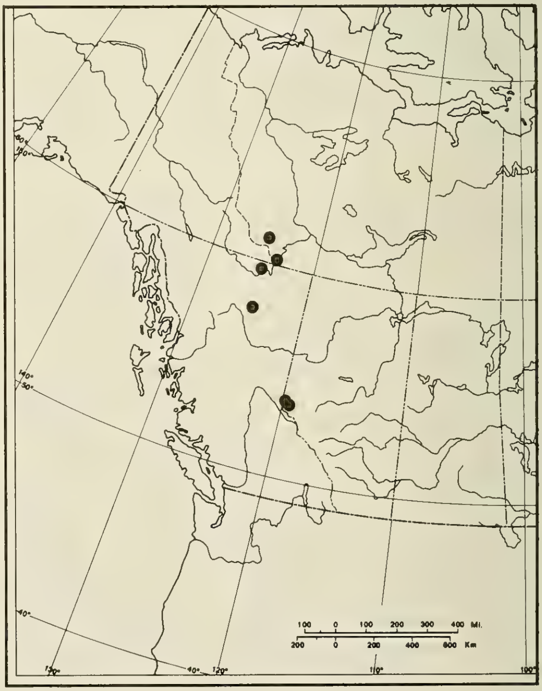

FIGURE 1. Known distribution of Raup's Willow, *Salix raupii*.

TABLE 1. Comparison of the morphology of *Salix raupii* with similar species.

Characters	*S. raupii*	*S. farriae*	*S. barclayi*	*S. pedicellaris*	*S. glauca*
Branchlet pubescence	glabrous	glabrous or sparsely pubescent	villous	glabrous	pubescent to villous
Leaf shape	elliptic to narrowly so	elliptic to elliptic-obovate	elliptic to obovate	oblong	obovate to elliptic
Leaf apex	obtuse or acute	acute	acute to acuminate	acute to rounded	acute to obtuse
Leaf pubescence (beneath)	glabrous	glabrous	glabrous or sparsely pubescent	glabrous	villous to glabrescent
Leaf pubescence (above)	glabrous	glabrate with ferruginous hairs on midrib	glabrescent with white hairs on midrib	glabrous and glaucous	glabrescent to villous
Leaf margin	entire or glandular-crenate	entire or glandular-serrulate	distinctly glandular-serrulate	entire	entire
Stipule length (mm))	1-3	up to 4	1.5-5 (20)	1-1.5	1-7(17)
Floral bract colour	lemon yellow or bicolour	brown to tawny	light to dark brown or bicolour	tawny	tawny or light brown
Floral bract pubescence	glabrous	sparsely lanate to glabrate	pubescent	glabrous	pubescent
Capsule length (mm)	4.4-8	4-5	5-6.5	5.5-6.5	3-8
Capsule pubescence	glabrous or with 2 longitudinal bands	glabrous	glabrous	glabrous	pubescent to glabrescent
Stipe length (mm)	0.4-1.2	0.8-1.5	0.4-1.4	2.1-3.2	0.25-2
Nectary length	equal or longer than stipe	$< 0.5 \times$ stipe	$0.5 \times$ stipe	$0.2\text{-}0.5 \times$ stipe	$0.4\text{-}2 \times$ stipe
Style length (mm)	0.6-0.8	0.4-1.2	0.6-1.6	0.1-0.2	0.5-1
Stigma length (mm)	ca 0.4	0.2-0.3	0.4-0.6	ca. 0.2	0.5-1

491. 25 August 1982. CAN. (Acronyms follow Boivin 1980.)

2. Kakwa Falls, approximately 400 yds upstream from falls on north side of river, 54°05′N, 119°40′W (approximate). *John Corbin & Peter van Eck 10283*. 8 August 1978. UAC.

NORTHWEST TERRITORIES:

3. South Nahanni River, 5 miles from confluence of Flat River, 61°30′N, 125°16′W. *S.S. Talbot T5055-7*. 26 July 1975. CAN.
4. Fisherman Lake, 60°20′N, 123°48′W. *Sheila M. Lamont FL149*. 22 June 1973. CAN.

BRITISH COLUMBIA (additional record):

5. Fern Lake, near and around outlet at east end of lake, 57°45′N, 124°47′W. *Erich Haber & George W. Argus 10667*. 5 August 1977. CAN.

Habitat

Salix raupii occupies a variety of habitats. In British Columbia and the Northwest Territories it is known from thickets in moist, open *Picea glauca, Populus tremuloides* woods on gravel floodplains, or in *P. tremuloides, P. balsamifera* woods. In the Northwest Territories it also occurs in *Picea mariana* treed bogs. In Alberta it has been collected in lush mountain meadows and in *Salix* fens where it is associated with other *Salix*.

Recognition

In this section I will compare *S. raupii* with species that it keys out with in the floras of western Canada and Alaska. Table 1 should be consulted for contrasting characteristics.

In my treatment of *Salix* for the Flora of Alberta (Moss 1983), specimens of *S. raupii* with prominent stipules key out with *S. barclayi* and *S. farriae*; *S. raupii* is not easily distinguished from some extreme variants of these species. It may be distinguished from *S. barclayi* by its glabrous branchlets, moderately sized stipules and its entire or very indistinctly toothed leaves. Lacking these characteristics, its glabrous floral bracts and nectaries equalling or exceeding the stipes are diagnostic. It is similar in some respects to *S. farriae* but it lacks the ferruginous hairs on the leaves of that species and it tends to have longer capsules, paler bracts, and longer nectaries relative to stipe length than *S. farriae*.

Specimens of *S. raupii* with small stipules or lacking stipules key out with *S. farriae* (distinguished as above) and *S. pedicellaris*. *S. raupii* is easily separated from *S. pedicellaris* by its leaf shape, the lack of glaucescence on its upper leaf surface, its longer styles and stigmas, and other characteristics in Table 1.

In floras of Alaska and the Yukon (Viereck and Little 1972; Argus 1973; Welsh 1974) stipulate plants of *S. raupii* key out with *S. barclayi* from which *S. raupii* is readily distinguished by its entire, glabrous leaves as described above. It also keys out with *S. barclayi* in Hultén's flora (1968). Plants lacking stipules key out with *S. hookeriana*, but is is not likely to be confused with this plant of coastal southeastern Alaska, which is a small tree or tall shrub with villous-lanate branchlets and pubescent leaves.

In the flora of the continental Northwest Territories (Porsild and Cody 1980) *S. raupii* keys out with the "*S. fuscescens* group", which includes *S. pedicellaris*, and with *S. barclayi, S. farriae, S. myrtillifolia*, and *S. commutata*. It may be distinguished from the first three species as described above. From *S. myrtillifolia* and *S. commutata* it is easily distinguished by leaves that are glaucous beneath; the leaves of the latter species are also tomentose on both sides.

Taxonomic Relationships

The relationships of *S. raupii* are no less equivocal today than when the species was first described (Argus 1974). At that time I discussed its relationship with the *S. glauca* complex and the possibility that it may be a hybrid involving that species. I have since observed well-formed pollen grains in the staminate flowers of two specimens, suggesting that they are not hybrids. Further collections of this species, especially population samples and chromosome number data, may help resolve this question.

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A North Sea Beaked Whale, *Mesoplodon bidens*, in Conception Bay, Newfoundland[1]

L. DIX, JON LIEN, and D. E. SERGEANT[2]

Newfoundland Institute for Cold Ocean Science and Department of Psychology, Memorial University of Newfoundland, St. John's, Newfoundland A1B 3X9
[2]Arctic Biological Station, Ste-Anne de Bellevue, Quebec H9X 3R4
[1]N.I.C.O.S. Contribution Number 91

Dix, L., Jon Lien, and D. E. Sergeant. 1986. A North Sea Beaked Whale, *Mesoplodon bidens*, in Conception Bay, Newfoundland. Canadian Field-Naturalist 100(3): 389–391.

A single male *Mesoplodon bidens*, 410 cm in total length, was entrapped in fishing gear once, and stranded twice, the final time fatally, between 24 and 26 July 1984. This is only the seventh animal reported seen in North America in the past 120 years.

Key Words: North Sea Beaked Whale, Sowerby's Beaked Whale, *Mesoplodon bidens*, Cetacea, Newfoundland.

The range of the North Sea Beaked Whale, most commonly known as Sowerby's Beaked Whale, *Mesoplodon bidens*, is poorly known, but based on stranding data, is thought to be centered in the North Sea (Moore 1966). Sergeant and Fisher (1957), in an account of small Cetacea in eastern Canadian waters, suggest *M. bidens* has a summer distribution in cooler, northern, offshore waters with the result that a few animals extend their feeding grounds to the North American coast, especially when the squid *Ilex illecebrosus* is plentiful.

Although there are 30 or so strandings of this species on the European coast and occasional sightings (Saemundsson 1939; Fraser 1953; Oynes 1974; Christensen 1977), there are only six recorded strandings and no verified sightings of the animal in North America. The first record of *M. bidens* in the Northwest Atlantic was in 1867 when an adult male was stranded on Nantucket Island, Massachusetts. A stranding of a 488 cm female occured in Nantucket Massachusetts on 10 September 1982 (New England Aquarium, MH-82-180). The most recent stranding, a 457 cm male, occurred in Port St. Joe on the Gulf Coast of Florida on 17 October 1984 (USNM 550414) (James G. Mead, personal communication).

The remaining three specimens of *M. bidens* in North America occurred in Newfoundland or Labrador. Two were recorded in consecutive summers (Sergeant and Fisher 1957). A 472 cm adult male was found dead in August, 1952 in Chapel Arm, Trinity Bay (47°45′N, 53°52′W). The second specimen, a 427 cm female, was harpooned at Wild Bight, Notre Dame Bay (49°40′N, 55°50′W) in September, 1953. The third, probably a female, came from Labrador (54°10′N, 58°35′W) in September, 1973 (James G. Mead, personal communication). In this report we describe the seventh animal seen in North America in the past 120 years.

On 24 July 1984 a fisherman reported to us that he had a live whale entrapped in fishing gear in Manuels, Conception Bay (47°35′N, 53°15′W). We photographed and freed this whale and later identified it from photographs as *M. bidens*. On 25 July a whale of the same description stranded live at Clark's Beach, Conception Bay (47°35′N, 53°15′W). Local people pushed the animal off the beach several times and finally the whale disappeared. From photographs, we are sure this was the same animal caught in fishing gear earlier.

The whale stranded once again near Port de Grave, Conception Bay (47°34′N, 53°11′W) on 26 July. In Port de Grave, we photographed and examined the freshly dead animal. It was the same whale that had stranded in Clark's Beach.

It was a male measuring 410 cm in total length. The colour was a uniform grey; the ventral colouring was somewhat lighter dorsal. The whale was covered with scratches, most of which appeared fresh and are believed to be the result of the fishing gear entrapment and previous stranding.

The dorsal fin was well back from the head; pectoral fins were set well forward in the body near the head. The beak measured 57 cm and a pair of prominent teeth protruded from the lower jaw. These lower teeth were triangular in shape, 5 cm per side and appear similar to those identified by Fraser (1953) as from a young male. Teeth in the upper jaw were very small and pointed, protruding about 1 cm. Cross-sections of the upper and lower teeth exhibited two light rings and one dark annulus. The stomach was empty except for two gadoid otoliths. The animal was free from external parasites; however, small circular scars (circa 2 cm) which were well healed were found in both dorsal and ventral areas. Viable sperm were not found

TABLE 1. Comparative body measurements from three specimens of *Mesoplodon bidens* found in Newfoundland. Measurements of the 1952 and 1953 animals are from Sergeant and Fisher (1957).

Measurement (in cm)	Locality / Date	Trinity Bay 25 Aug 52	Notre Dame Bay 25 Sept 53	Conception Bay 26 July 84
Tip of snout to edge of fluke		472	427	410
Tip of snout to slit of blowhole		56	55	57
Tip of snout to angle of mouth		36	28	45
Tip of snout to anterior insertion of flipper		100	56	60
Total spread of flukes		—	—	98
Edge of flukes to posterior of dorsal fin		162	—	129
Dorsal fin, length at base		15	—	24
Dorsal fin, greatest vertical height		20	—	15
Flipper, axilla to tip		36	—	35
Flipper, anterior border to tip		48	—	47
Flipper, greatest width		16	—	12
Girth at level of axilla		254	—	210
Girth at anterior end of dorsal fin		239	—	180
Tooth count		LORO 11	LORO 11	L9R11 11

in the testes and the animal was considered immature. From our gross examination of internal organs we could not determine a cause of death. Measurements of this specimen and two previous Newfoundland animals are presented in Table 1.

The infrequent reports of *M. bidens* in the northwestern Atlantic would suggest that it is rare in Newfoundland and Labrador waters. It is difficult to identify at sea (Oynes 1974), so the absence of live sightings is not unusual. However, because of the presence of the unusual beak it is likely that most stranded animals would be reported to officials.

Although we have examined oceanographic data from 1952-1953, 1962, 1973 and 1984, there are no obvious similarities in those years which differ from other years and might account for observations of this species in North American waters (Branson and Soule 1953; Bush et al. 1955; MEDS 1981). During 1952-1953, when Sergeant and Fisher (1957) obtained *M. bidens* in Newfoundland, squid (*I. illecebrosus*) were extremely abundant. However, squid were very scarce in 1973 and 1984 (F. A. Aldrich, personal communication) and fish otoliths were found in this animal's stomach. This suggests that the occurrence of *M. bidens* in Newfoundland and northwestern Atlantic waters, if cyclic, is correlated with yet unknown biological and oceanographic factors.

Acknowledgments

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A Northern Record of the Water Shrew, *Sorex palustris*, from the Klondike River, Yukon Territory

GORDON H. JARRELL

Institute of Arctic Biology, University of Alaska, Fairbanks, Alaska 99775

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A Water Shrew, *Sorex palustris*, captured at 64° 30′N, 138° 14′W on the North Klondike River, Yukon Territory, suggests this species is widely distributed in the Yukon River drainage.

Key Words: Water Shrew, *Sorex palustris*, distribution, Yukon Territory.

Water Shrews (*Sorex palustris*) are not commonly captured unless traps are set specifically for them, so the northern limit of their distribution is not fully described. The species ranges west to Iliamna Lake, near the base of the Alaska Peninsula and north into the central Alaska Range (MacDonald and Elliott 1984). Water Shrews are previously known from the southern Yukon Territory (Youngman 1975), the central District of Mackenzie (NWT), and east to Churchill, Manitoba (Hall 1981).

On 21 July 1984, an adult male Water Shrew (University of Alaska Museum 15797) was captured in the Ogilvie Mountains of Yukon Territory, near the confluence of Lignite Creek and the Klondike River (64° 30′N, 138° 14′W) at Tombstone Mountain campground 76 km northeast of Dawson. The shrew was captured in an unbaited Museum Special snap trap set in the water at the edge of the creek. A Northern Red-backed Vole (*Clethrionomys rutilus*) and a Long-tailed Vole (*Microtus longicaudus*) were captured at the same site.

This record is only slightly north of the latitudinal extremes for the Water Shrew in Alaska (63° 51′N: MacDonald and Elliott 1984) and Northwest Territories (63° 32′N: Hall 1981), but it extends the documented range in Yukon Territory (Youngman 1975) about 300 km north. This specimen is the only known occurrence of the Water Shrew north of the Yukon River, and in view of the recent Alaska records, it suggests that the Water Shrew could be widely distributed within the Yukon drainage.

Acknowledgments

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Breeding of Wilson's Phalarope, *Phalaropus tricolor*, at Churchill, Manitoba

M. A. BOUSFIELD,[1] I. R. KIRKHAM,[2] and R. D. MCRAE[3]

[1]1302-2861 Baycrest Drive, Ottawa, Ontario K1V 8X8
[2]#57-28 Livingston Road, Scarborough, Ontario M1E 4S5
[3]623 Homewood Avenue, Peterborough, Ontario K9J 4V4

Bousfield, M. A., I. R. Kirkham, and R. D. McRae. 1986. Breeding of Wilson's Phalarope, *Phalaropus tricolor*, at Churchill, Manitoba. Canadian Field-Naturalist 100(3): 392–393.

Downy young and juvenile Wilson's Phalaropes (*Phalaropus tricolor*) were observed for the first time around Churchill, Manitoba in July 1984. An increase in sightings during the past decade may indicate increased usage of suitable habitat throughout the Hudson Bay lowlands during drought conditions on the Prairies.

Key Words: Wilson's Phalarope, *Phalaropus tricolor*, breeding, Churchill, Hudson Bay lowlands.

On 12 July 1984, a male Wilson's Phalarope, *Phalaropus tricolor*, was observed on the muddy shore of a tundra pond near the town of Churchill, Manitoba (58°45′N, 94°00′W). This phalarope exhibited signs of territorial behaviour by moving from side to side of a small (100 × 54 m) island. The island consisted of a dry central area where *Primula egaliksensis* (primrose), *Epilobium angustifolium* (Fireweed), and *Stellaria longipes* (chickweed) were common amongst the short grasses, and of a periphery dominated by tall (up to 1 m) *Carex aquatilis* and *C. physocarpa* (sedges) with some *Trisetum spicatum* (a grass) and *Eriophorum* spp. (cottongrass).

The phalarope ran and flew in circles with its neck held alternately upright and low and extended forward. It made the peculiar, nasal "wunk" call common in this species (see Höhn 1967; Howe 1975a). On the following day, a pair of phalaropes was observed at the same location, with the male behaving as described previously. In the evening of 15 July, the male circled over the centre of the island before landing there. Three downy young were immediately located on dry ground amongst 30 cm high grasses and sedges. A thorough search of the area then and on the following day revealed no more than three chicks. The male called and circled low overhead while the chicks were banded.

On the basis of culmen, tarsus, and weight measurements (see Table 1), the chicks were judged to be 1-2 days old (i.e. hatched on 14 or 15 July). Godfrey (1986) noted the incubation period for Wilson's Phalarope as 20.2 days. Eggs are laid 24.4 (Kagarise 1979) to > 39 hours apart (Howe 1975b). Thus, the clutch of the observed male most likely was initiated between 19 and 22 June, similar to dates given for Red-necked Phalaropes, *P. lobatus*, nesting at Churchill (Taverner and Sutton 1934; Jehl and Smith 1970). Sinclair (1978) recorded egg laying between 26 May and 27 June 1977 for Wilson's Phalaropes at South Marsh on James Bay, Ontario.

TABLE 1. Body measurements of three Wilson's Phalarope chicks banded at Churchill on 16 July 1984 and mean values found in chicks at South Marsh (SM) in July 1976 and 1977 within 12 hours of hatching (from Sinclair 1978).

	Body Measurements		
Chick	Weight (g)	Tarsus (mm)	Culmen (mm)
A	6.8	16.6	10.4
B	7.4	20.0	10.6
C	8.1	19.1	11.8
SM mean	7.16	22.31	8.75
+ s.d.	0.57	1.77	0.60
(n = 22)			

By 22 July the chicks were no longer encountered in the immediate vicinity. However, a male phalarope called and circled around us between 60 and 150 m from where the chicks had been found, so it seems probable the young were still in the general area.

On 4 August, we saw an adult male and seven juvenile Wilson's Phalaropes feeding around the ponds near the base of the grain elevator in Churchill. The legs of five juveniles were visible and were unbanded. This sighting indicates that at least three broods of Wilson's Phalaropes were raised near Churchill in 1984.

According to Godfrey (1966), the known breeding range of the Wilson's Phalarope in Manitoba extends from the southern border north to Reader and Halcrow lakes (near The Pas), about 675 km south of Churchill. Heydweiller (1935) had reported a breeding Wilson's Phalarope in the Churchill area, but Jehl and

Smith (1970) felt that Heydweiller's identification was in error, based on the very low egg weights, and concluded that these were Red-necked Phalaropes. Breeding has been reported from similar habitat south of Churchill at North Point (51°29′N, 80°27′W), James Bay. In his revised work, Godfrey (1986) has incorporated our present record. Morrison and Manning (1976) regularly encountered small numbers of Wilson's Phalaropes at North Point during August 1974 and May-August 1975. Sinclair (1978) found 20-25 nests about 5 km from North Point in 1976 and 1977. In July 1984, M. Gartshore and C. Risely observed nesting behaviour in Wilson's Phalaropes in two locations in "wet fen" in northwest Ontario near Sandy Lake (53°13′N, 93°59′W and 53°16′N, 93°29′W; Ontario Breeding Bird Atlas Newsletter No. 11).

No breeding behaviour, nests, downy young, or juveniles have been reported previously for Churchill, despite the large number of birdwatchers and ornithologists who now regularly visit the area. Increased observation has, however, revealed that Wilson's Phalaropes occur regularly but infrequently in the region. B. Chartier (personal communication) reported single Wilson's Phalaropes on 17 May 1977, 18 June 1978, and 14 July 1979. These individuals were assumed to have been non-breeders. In 1984, between one and six Wilson's Phalaropes were sighted between 30 May and 20 June. Although this species can be easily overlooked and may have been missed previously, the exceptional number of sightings in the spring and summer of 1984 appears to indicate a real increase in the number of these phalaropes in this area. This influx likely followed drought conditions on the Prairies which could have driven these prairie-pothole nesters to seek nesting sites wherever traditional habitat conditions could be found. Such a search might cause birds to fly beyond the unsuitable habitat of the boreal forest to northern tundra. Churchill lies less than 2 km north of the tree line.

The habitats in which the breeding males were encountered at Churchill and at North Point are qualitatively similar. It is likely that this species nests in small numbers wherever suitable habitat occurs throughout the Hudson Bay lowlands, with the numbers increasing whenever unfavourable nesting conditions exist on the Prairies.

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The Shortbarbel Dragonfish, *Stomias brevibarbatus*, New to the Fish Fauna of the Atlantic Coast of Canada

BRIAN W. COAD

Ichthyology Section, National Museum of Natural Sciences, Ottawa, Ontario K1A 0M8

Coad, Brian W. 1986. The Shortbarbel Dragonfish, *Stomias brevibarbatus*, new to the fish fauna of the Atlantic coast of Canada. Canadian Field-Naturalist 100(3): 394–395.

A specimen of the Shortbarbel Dragonfish, *Stomias brevibarbatus* (family Stomiidae or scaled dragonfishes [dragons à écailles (m.) en français]), was caught southwest of Sable Island, Nova Scotia (42°08′09″N, 62°59′00″W) on 3 February 1982. This is the first Canadian record of the species and extends the range northwards from Bermuda, the Carolina coast of the U.S.A. and latitude 40°N in the Atlantic Ocean. No significant differences were found between the specimen at hand and literature descriptions.

Key Words: Shortbarbel Dragonfish, *Stomias brevibarbatus*, new record, Nova Scotia.

A specimen of *Stomias brevibarbatus* was caught by the vessel *Lady Hammond* in a midwater trawl fishing down to 500 metres southwest of Sable Island, Nova Scotia (42°08′09″N, 62°59′00″W) on 3 February 1982 at 2200 h. This is the first record of this species from Canada and extends the range northwards from Bermuda, the Carolina coast of the U.S.A. and 40°N in the Atlantic Ocean. This species is a member of the scaled dragonfish family Stomiidae (or Stomiatidae).

This note documents the record and gives a detailed description and illustration of the specimen (Figure 1) in the format of *Fishes of the Atlantic coast of Canada* by Leim and Scott (1966). Additional information was taken from Morrow (1964), Gibbs (1969) and Shcherbachev and Novikova (1976).

Shortbarbel Dragonfish **Dragon Vert**

Stomias brevibarbatus Ege, 1918

DESCRIPTION: Body slender, maximum depth 8.6 times in standard length (SL), compressed, depth greater than width, caudal peduncle short, compressed and deep (depth in length 2.1). Head longer than deep, 9.1 times in SL, snout short and blunt, 5.1 times in head length (HL), orbit moderate, 4.6 times in HL, interorbital space flat, 4.6 times in HL, 1.0 times in orbit diameter. Barbel on chin short, 1.8 times in HL, ending in a rounded bulb with three (fourth possibly lost) filaments, each about same length as the bulb. Mouth gape almost the same length as the head. Premaxilla with one small anterior tooth followed by a large, fang-like tooth and 6-7 smaller ones. Premaxilla length 1.4 times in HL and longest tooth 4.4 times in premaxilla length. Maxilla slightly larger than premaxilla and bearing minute, recurved teeth on its outer, ventral margin. Lower jaw longer than upper jaw and projecting slightly with about 11-13 small teeth. Vomer with one small, backward-pointing tooth on each side. Palatines each with a single large anterior tooth (a double tooth on the left in this specimen) and a smaller posterior tooth. Dorsal and anal fins far posterior on the body near the caudal fin. Anal fin longer with 20 rays (length of base in SL 8.4). Dorsal fin with 17 rays (length of base 10.5 times in SL). Predorsal length 1.2 times in SL and preanal length 1.2 times in SL. Pelvic fins nearer to caudal fin

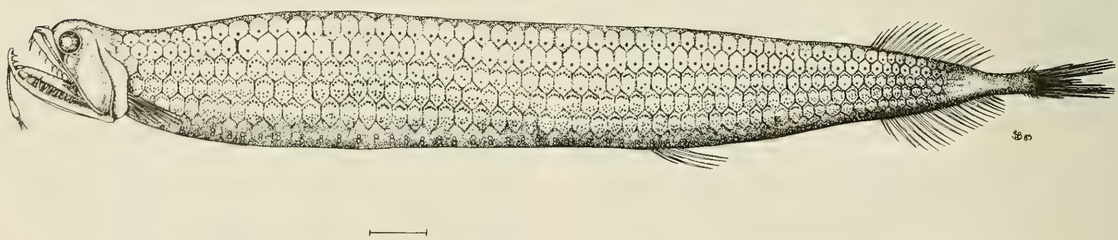

FIGURE 1. *Stomias brevibarbatus*, 184.8 mm SL from southwest of Sable Island, Nova Scotia (NMC84-0279). Drawn from the preserved specimen by S. Laurie-Bourque.

than to head, prepelvic distance 1.7 times in SL. Pelvic fins do not reach to the anal fin. Pelvic rays number five. Caudal fin small and forked. Pectoral fins low on the body with eight rays. Vertebrae number 64. Scales transparent and arranged in five longitudinal rows, each scale outlined with iridescent pigment in the shape of a hexagon. The most dorsal row contains a single (rarely two), ventral photophore and the second row a single (rarely two) photophore slightly below the centre. The third row has an arch of photophores dorsally and a more irregular group ventrally numbering 4-8 in total. The fourth row has a dorsal arch of 3-6 photophores with 5-9 photophores scattered below. The fifth row has 11-20 photophores arranged as in the fourth row. The most posterior scale areas tend to have fewer photophores than the larger, anterior scales. Below the most ventral scale row is a lateral and a ventral row of large photophores. The lateral row has 34 photophores from the head to the origin of the pelvic fin and 14 photophores posterior to this for a total of 48 photophores. The ventral row has 11 photophores on the isthmus to the origin of the pectoral fin, 34 photophores from the origin of the pectoral fin to the origin of the pelvic fin, 13 from the pelvic fin origin to the anal fin origin, and 15 posterior to this for a total of 73. The lateral and ventral rows have a wavy band of minute photophores between them and the "waves" extend between the large photophores of each major row. A double row of minute photophores is found ventral to the ventral row of large photophores and this extends dorsally between each large photophore. There is a photophore behind the eye which is about twice as long as its maximum width and is about three-quarters the size of the eye. The branchiostegal rays number 17 and each membrane between the rays bears a photophore.

COLOUR: In the preserved specimen the head and body are dark brown to black. The postorbital photophore and the photophores of the ventral and lateral rows are cream. Other photophores are darker than the background. Fins are pale. The flanks retain iridescent tinges. The barbel is pale and cream in colour. The oral cavity and the peritoneum are dusky. Live fish are iridescent dark green.

DISTINCTIONS: This species is separated from other *Stomias* in having five rows of pigmented scale areas dorsal to the lateral row of large photophores, a short barbel ending in an almost spherical bulb with 3-4 simple filaments, a large fang-like tooth on each premaxilla, 4-10 photophores in each hexagonal scale of the third row and 11-20 in the fifth row.

SIZE: The specimen described here at 200 mm total length is the largest known specimen.

RANGE: Recorded from a number of collecting stations across the Atlantic Ocean between about 16°N and 42°N from waters off the Iberian Peninsula to waters off Nova Scotia, the Carolina coast of the U.S.A. and Bermuda but not the Caribbean Sea.

Canadian distribution: Known only from a single specimen taken at 2200 h on 3 February 1982 by the vessel *Lady Hammond* southwest of Sable Island, Nova Scotia (National Museum of Natural Sciences catalogue number NMC 84-0279).

BIOLOGY AND ECONOMICS: Almost nothing is known of this species' biology and economics. It is less common than other *Stomias* species although it appears to be most common at depths of about 500-1500 metres in the daytime and 100-200 metres at night.

Acknowledgments

I am indebted to Douglas Markle, Huntsman Marine Laboratory, New Brunswick for confirming collection data. D. E. McAllister, Curator of Fishes, National Museum of Natural Sciences, confirmed my identification and proposed the new English name. Sybil Stymeist, working at the Huntsman Marine Laboratory for a Summer Canada 1984 project under the direction of André Emond, sent the specimen and collection data to the National Museum of Natural Sciences, Ottawa.

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Notes on the Sexual Cycle of Some Baffin Island Birds

ADAM WATSON

Institute of Terrestrial Ecology, Banchory, Scotland

Watson, Adam. 1986. Notes on the sexual cycle of some Baffin Island birds. Canadian Field-Naturalist 100(3): 396–397.

The gonad size of shot Rock Ptarmigan (*Lagopus mutus*), redpolls (*Carduelis flammea* and *C. hornemanni*), Lapland Longspurs (*Calcarius lapponicus*), and Snow Buntings (*Plectrophenax nivalis*) was noted. Gonads were at full size in late May and early June. Testes of Lapland Longspur and Snow Bunting were declining rapidly by the beginning of July, when the light cycle was very similar to midsummer.

Key Words: Sexual cycle, Rock Ptarmigan, *Lagopus mutus*, redpolls, *Carduelis flammea, Carduelis hornemanni*, Lapland Longspur, *Calcarius lapponicus*, Snow Bunting, *Plectrophenax nivalis*, Baffin Island.

The sexual cycle of arctic birds is of interest because day length changes so quickly and the summer is so short for breeding. These notes were made on the 1953 expedition by the Arctic Institute of North America to Cumberland Peninsula, Baffin Island, N.W.T. at about 67°N. Other bird observations have already been published (Watson 1957). The number of specimens (in Table 1) was small, but the differences in sexual cycle were so large as to be obvious. Scientific names are in Table 1.

Testes and combs of Rock Ptarmigan were enlarged in late May. Testes in August were almost down to the winter size in north Greenland (Johnsen 1953).

Redpoll testes were already at full size in late May, and declined later than in Lapland Longspurs and Snow Buntings. Males on 3 and 16 July in Owl Valley had testes as big as in June, and histological examination of one testis from 16 July showed large tubules with many sperms inside and active spermatogonia. This male had only a few pigmented feather follicles on the inside of the skin on its head, and lacked external sheaths or feather growth. I found no external sign of moult in late July and early August on many adult redpolls seen at close range through binoculars, though moulting was well advanced by the end of August. Redpolls continued singing until at least late July (when I left Owl Valley for two weeks), and I saw sexual display on 16 July (Watson 1957).

The testes of Lapland Longspurs grew rapidly at the end of May and early June, and were full-sized for only about a month. The testis decline was very rapid. In Swedish Jämtland, at about the same latitude but with a warmer and longer summer, males on 8 July had large testes, with a mean length of 9.8 mm, and a female had an egg in her oviduct (Salomonsen 1949). The testes of the Baffin Island birds showed an earlier regression than in Snow Buntings, and correspondingly the male moult began earlier and singing ended earlier (Watson 1957).

Testes of Snow Buntings were already large at the end of May, stayed enlarged through June, and decreased greatly from early July to early August.

At the end of May–beginning of June, when passerine birds first arrived, redpoll testes were at full size, and testes of Snow Buntings nearer to full size than in Lapland Longspurs. This corresponded with the observed early breeding of redpolls, with Snow Buntings slightly later and Longspurs later still (Watson 1957). Longspurs nested in wet grass-heath on valley bottoms which were snow-covered or waterlogged in early June and had frozen, ice-laden soil close to the ground surface. Snow Buntings nested in holes among boulders, places which thawed and dried out earlier. Redpolls nested in dry heaths, particularly along moraines, which carried little snow, were well drained with little ice in the surface soil, and had a better microclimate (Watson 1957), so that the ground thawed and warmed more quickly.

Testes of Lapland Longspur and Snow Bunting were declining rapidly in size by the beginning of July, when the light cycle was very similar to midsummer. It is now well established by experiment that prolonged exposure to long days, without any decline in light or day length, causes many birds, including arctic Willow Ptarmigan (*Lagopus lagopus*), to become photorefractory; in this state, the prevailing photoperiod cannot maintain the gonads in breeding condition (Stokkan et al. 1982).

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TABLE 1. Data from shot specimens on Cumberland Peninsula, Baffin Island, N. W. T.

Species	Place	Date	Gonad and comb measurements in mm*
Rock Ptarmigan (*Lagopus mutus*)	Near Durban Island	28 May	14.1, 10.0;11.0, 8.9 (comb 21.0, 11.0; 21.0, 12.0)
		29 May	14.5, 10.8; 14.9, 10.8 (comb 21.0, 11.0; 21.0, 10.5) Ovary shot (comb 15.0, 6.5; 15.0, 6.0)
	June Valley	20 June	Shot (comb 22.0, 12.0; 21.5, 12.0)
	Summit Lake	1 Aug.	4.6, 3.2; 4.2, 2.6 (comb 17.3, 8.1; 17.6, 7.9)
		2 Aug.	4.4, 3.1; 4.1, 2.3 (comb shot)
Common Redpoll (*Carduelis flammea*)	Near Durban Island	28 Aug.	7.2, 5.0; 6.0, 5.0
		29 Aug.	6.5, 4.7; 5.6, 5.1
	Owl Valley	3 July	7.2, 5.1; 5.9, 5.0
		9 July	c. 7, 5
		16 July	7.4, 5.8; 6.4, 5.9. Ovary 4.7, 4.3; oocyte 1.3
Hoary Redpoll (*Carduelis hornemanni*)	Cape Searle	24 May	6.5, 4.8; 5.6, 5.0
Lapland Longspur (*Calcarius lapponicus*)	Cape Searle	26 May	5.9, 4.4
	Padle Fiord	2 June	6.5, 5.7
	Owl Valley	9 June	9.9, 8.3
		27 June	10.1, 6.8; 9.1, 10.0
		29 June	10.0, 8.5; 9.5, 8.0. 10.5, 7.1; 9.4, 6.7
		4 July	4.2, 3.1; 3.9, 2.8
		11 July	Shot; 2.7, 1.7. 2.5, 1.8; shot
		13 July	2.8, 1.8; 2.6, 2.0
Snow Bunting (*Plectrophenax nivalis*)	Cape Searle	24 May	8.0, 4.9. 7.9, 5.0
	Near Durban Island	29 May	8.2, 5.1; 7.8, 4.8
	Padle Fiord	2 June	9.1, 5.1; 8.9, 5.0
	Owl Valley	11 June	9.0, 5.0; 8.6, 5.0
		12 June	8.1, 4.9
		24 June	9.4, 5.2. 9.2, 4.8. 6.8, 4.7. 8.3, 5.0
		29 June	10.4, 5.7
		2 July	5.8, 3.7
		3 July	4.0, 2.9
		6 July	5.0, 3.5
		11 July	4.2, 3.0; 3.6, 3.1
		12 July	4.6, 3.3; 4.4, 3.3
		13 July	4.1, 3.0; shot
		25 July	3.0, 2.5
	Summit Lake	29 July	length × breadth < 2
		4 Aug.	length × breadth < 2

*All males, unless ovary is mentioned. In order, measurements are given for left testis maximum length and breadth to the nearest 0.1 mm; right testis maximum length and breadth (in brackets left comb's maximum length and height to nearest 0.5 mm; right comb's maximum length and height). For females, maximum length and breadth of ovary to nearest 0.1 mm; diameter of biggest oocyte. Where there are only two figures for a male, they give the maximum length and breadth of the larger testis. Extra birds on same date are shown after a full stop.

News and Comment

Notice of The Ottawa Field-Naturalists' Club Annual Business Meeting

The 108th Annual Business Meeting of the Ottawa Field-Naturalists' Club will be held in the auditorium of the Victoria Memorial Museum Building, Metcalfe and MacLeod Streets, Ottawa on Tuesday, 13 January 1987 at 2000 h.

ELEANOR BOTTOMLEY
Recording Secretary

The Great Buffalo Saga: A Film Review

Written and directed by Boyce Richardson, produced by Mark Zannes, issued in 1985 as a co-production of the National Film Board and Parks Canada.

The Great Buffalo Saga bills itself as "an incredible story of the bison's rescue from extinction." It *is* an incredible story, but this film tells only a small portion of it, and imperfectly at that. It explores three themes: the development of scientific management and handling techniques, the preservation of a remnant herd of Plains Bison (the "Pablo-Allard" herd), and some problems relating to bison in Wood Buffalo National Park.

The film begins with a round-up of Wood Bison from Elk Island Park for transport to an Indian reserve in northwestern Alberta. Curiously, the remainder of the first reel switches the viewer's attention away from the Wood Bison to the Pablo-Allard herd of Plains Bison obtained in Montana. These Plains Bison were relocated to a fenced parkland reserve established for them at Wainwright. A highlight of the film is some marvellous archival footage of the bison in Montana and at Wainwright, including their use in Hollywood films. The film points out that the bison rapidly exceeded the carrying capacity of the range, leading to the need for periodic slaughters to cull the herd. They also became infected with tuberculosis and brucellosis through their contact with cattle.

Government officials responded to the public outcry against these slaughters by deciding to relocate over 6000 young Plains Bison to the less densely populated ranges of Wood Buffalo Park between 1925 and 1928. Some brief footage of this move is included in the film, which outlines the controversies about this decision. Biologists worried that the Plains Bison (*Bison bison bison*) would interbreed with the northern Wood Bison (*B. b. athabascae*) which the park was intended to protect. Government officials decided that the bison would use different trail systems and therefore should not have an opportunity to mingle; in fact, the two subspecies did intermingle. A second concern was that the Wainwright bison were known to carry tuberculosis and brucellosis, diseases which were not believed at that time to infect the Wood Bison. However, the Plains Bison were not screened for tuberculosis prior to being selected for shipping, since government officials had decided that only old bison were susceptible to infection, not the young ones being shipped. This premise also proved faulty.

It is at this point that the film begins to lose its integrity. While part of the "great buffalo saga" involves the northern Wood Bison, the film does not explain how they came to be saved from the extinction which threatened them in the late 19th century. Their "rescue" begain in 1894 when the hunting of Wood Bison was prohibited with the passing of the Unorganized Territories Game Preservation Act. These northern bison were the last free-ranging bison in North America, and the history of their preservation is complex and fascinating (*see* McCormack 1984 for a detailed explanation). It involved the establishment of Wood Buffalo Park and a warden service in 1922 and the provision of hunting and trapping privileges for Treaty 8 Indians.

The film does not present information on the subsequent "management" of the park bison, which was complicated by the arrival of the Wainwright bison in 1925. They were released on the west bank of the Slave River and promptly left the park for the lush meadows of Lake Claire south of the Peace River. In 1926, the federal government annexed the area which is now the southern half of the park and provided hunting, trapping, and trading privileges for users of the immediate region — Indians, Metis, and Europeans.

A small annual bison slaughter program to supply meat for the residential schools and for Indian Affairs relief programs was allowed in the park, but subsistence hunting of park bison continued to be

prohibited, even after strict limits were imposed on the Moose harvest in the mid 1940s. In the late 1940s, however, park officials became concerned about the tuberculosis which was by then endemic among the park bison. They decided to implement a commercial slaughter program designed to eradicate tuberculosis and at the same time provide cheap meat for northern markets. Bison were tested for tuberculosis, and reactors were slaughtered. However, the high costs of this program meant that bison meat was not competitive with imported beef. Prime cuts were sold to southern markets to subsidize the cheaper cuts sold in the north. When meat orders expanded, young, healthy animals were killed to make up the meat order. Commercial slaughters continued until 1967, when the last bison were slaughtered to provide meat for the World's Fair in Montreal. The fact that this slaughter operation is not even mentioned in the film may suggest that Parks Canada today considers it an embarrassment as a "game management program", but it was an important episode in the history of the park bison and should have been part of the film.

The film does mention the anthrax epidemics of the 1960s, but it does not discuss the management strategy which was proposed by park biologists: the possibly permanent empoundment of all bison in the park so that they could be vaccinated regularly against the disease. Nor does it consider the potentially positive role of the controlled burning practised by Natives before the establishment of Wood Buffalo Park. Controlled burning would not only have destroyed long-lasting anthrax spores, it would also have enhanced diminishing pastures for bison and other fur and game species.

Having managed to omit most of the history of the development of strategies for northern bison preservation and management, the film then moves to a discussion of the differences between Wood and Plains bison and of efforts to preserve a small population of Wood Bison which were believed never to have interbred with the Plains Bison. This discussion is followed by a series of poorly related and often trivial anecdotes. The film finishes by going back to its starting point, the release of bison in northern Alberta.

The film is strongest when it traces the odyssey of the Pablo-Allard herd from Montana to Wainwright and Wood Buffalo Park. However, this may be its only real focus, since it has no clear objective after it moves to other topics. It also has a southern bias. One suspects that the film-makers were enticed by the exciting archival footage they were able to locate and that they knew very little about the history of the bison in Wood Buffalo National Park. It does not appear that they spent any time talking with Native people about the bison in the park, since the film reflects no local Native concerns. While there are long interviews with people involved with the Wainwright bison, there are none with the northern Natives or older wardens who would have contributed valuable perspectives.

The film presents what it refers to as "decades of a program of scientific management." This is a generous assessment of what were really decades of a program of *ad hoc*, "commonsense" policies based on little or no scientific understanding of ecological relationships and occasionally on political expediency. Detailed biological studies of the park bison did not begin until after World War II. This film should be used with care, as one that contains some interesting footage but offers only a very limited understanding of how the northern Bison — including those from Wainwright — came to be saved from extinction.

PATRICIA A. MCCORMACK
Curator of Ethnology, Provincial Museum of Alberta, 12845-102 Avenue, Edmonton, Alberta T5N 0M6

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Editor's Note

Readers interested in evaluation of the geographic variation and status of bison should refer to the recent publication:

van Zyll de Jong, C. G. 1986. A systematic study of Recent Bison, with particular consideration of the Wood Bison (*Bison bison athabascae* Rhoads 1898). National Museums of Canada, Publication in Natural Sciences 6, viii + 69 pp.

Rare and Endangered Plants of Canada: Report of the Plants Subcommittee, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC)

Erich Haber

Botany Division, National Museum of Natural Sciences, Ottawa, Ontario K1A 0M8

Haber, Erich. *Editor*. 1986. Rare and Endangered Plants of Canada: Report of the Plants Subcommittee, The Committee on the Status of Endangered Wildlife in Canda (COSEWIC). Canadian Field-Naturalist 100(3): 400–403.

This review summarizes the status of report preparation on rare species of vascular plants in Canada by the Plants Subcommittee of the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Thirty-five species have been assigned official COSEWIC status with 19 other status reports in preparation or under review. The largest number of reports completed (with and without status) or under preparation (34) is for species occurring, at least in part, in Ontario. Two tables provide a breakdown by province of species with COSEWIC status designations and status reports completed or in preparation.

Key Words: COSEWIC, Canada, rare and endangered plants.

The Plants Subcommittee of the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was formed in 1980, with George Argus from the National Museum of Natural Sciences as its first chairman (for a review of the history of COSEWIC and its subcommittees see Cook and Muir 1984, and Campbell 1984). Several professional botanists selected by the chairman from across Canada serve on the subcommittee as advisors and reviewers of status reports.

The first main task of the subcommittee was to prepare a list of rare Canadian species that would serve as candidates for the preparation of status reports. Argus compiled such a list in 1980, using available published and unpublished lists of rare plants. For the most part, these were the lists of provincial rare plants published by Argus and various collaborators in the Museum's *Syllogeus* series, including Alberta, Continental Northwest Territories, Manitoba, Nova Scotia, Ontario, Saskatchewan, and Yukon. Since that time, lists have been published for New Brunswick, Quebec, and British Columbia. In the 1985 revised list of candidate species now in use, five categories of rare plants are recognized:

1. Rare Canadian endemics.
2. Rare Canadian peripheral species that are endangered, threatened, or rare throughout their total range.
3. Rare Canadian peripheral species that are endangered, threatened, or rare in two or more American border states.
4. Rare Canadian peripheral species that are endangered, threatened, or rare in one American border state.
5. Rare Canadian peripheral species that occur at only a few localities, but for which no official status is known outside Canada.

These five categories represent a priority selection of those rare species most in need of investigation. It was recognized, however, that stringent adherence to the priority listing of species for the preparation of status reports need not be followed. The reasoning was that many species, including Canadian endemics, occur in remote areas where no threats exist; on the other hand, some rare peripheral species that occur in populated regions are under imminent threat. The selection of species for report preparation is also influenced by the interests of potential authors.

Some species are of particular significance due to specific agents causing rarity: for example, the Chestnut, *Castanea dentata*. This once valuable hardwood tree species was decimated by the chestnut blight throughout its range, and now exists primarily as clonal root sprouts and the occasional young fruit-bearing tree. Its status in Ontario has been investigated in order to obtain an up-to-date inventory of this important genetic resource.

Status reports from member agencies of COSEWIC or from contract authors are reviewed by the subcommittee, and, as well, are sent to the respective agencies under whose jurisdiction the species occurs. Any comments and additional information are incorporated into the edited report. This is submitted by the subcommittee along with its status recommendation to COSEWIC for review by its members and subsequent status designation at the annual meeting in April.

Status Report Summary

The current revised list of candidates for report

TABLE 1. List of plant species with designated COSEWIC status as of April 1986.

Scientific Name	Common Name	Province	Status* & Year
***Adiantum capillus-veneris*	Southern Maidenhair Fern	BC	E/1984
Arisaema dracontium	Green Dragon	Ont, Que	R/1984
Armeria maritima subsp. *interior*	Thrift	Sask	T/1984
***Azolla mexicana*	Mosquito Fern	BC	T/1984
Buchnera americana	Bluehearts	Ont	T/1985
Celtis tenuifolia	Dwarf Hackberry	Ont	R/1985
Clethra alnifolia	Sweet Pepperbush	NS	T/1986
Coreopsis rosea	Pink Coreopsis	NS	E/1984
Cypripedium candidum	Small White Lady Slipper	Man, Ont	E/1981
***Epipactis gigantea*	Giant Helleborine	BC	T/1984
Floerkea proserpinacoides	False Mermaid	Ont, Que, NS	NIAC/1984
Fraxinus quadrangulata	Blue Ash	Ont	T/1983
Geum peckii	Eastern Mountain Avens	NS	E/1986
Gymnocladus dioica	Kentucky Coffee Tree	Ont	T/1983
Hydrocotyle umbellata	Water-pennywort	NS	E/1983
Isotria medeoloides	Small Whorled Pogonia	Ont	T/1982
Isotria verticillata	Long Whorled Pogonia	Ont	E/1986
Justicia americana	American Water-willow	Ont, Que	T/1984
Lespedeza virginica	Slender Bush-clover	Ont	E/1986
Magnolia acuminata	Cucumber Tree	Ont	E/1984
Opuntia humifusa	Eastern Prickly Pear Cactus	Ont	E/1985
Pedicularis furbishiae	Furbish Lousewort	NB	E/1980
Phegopteris hexagonoptera	Broad Beech Fern	Ont, Que	R/1983
Plantago cordata	Heart-leaved Plantain	Ont	E/1985
Platanthera leucophaea	Prairie White Fringed Orchid	Man, Ont	R/1986
Polygala incarnata	Pink Milkwort	Ont	E/1984
Potamogeton hillii	Hill's Pondweed	Ont	R/1986
Ptelea trifoliata	Hop Tree	Ont	R/1984
Pycnanthemum incanum	Hoary Mountain Mint	Ont	E/1986
Quercus shumardii	Shumard Oak	Ont	R/1984
Rosa setigera	Climbing Prairie Rose	Ont	R/1986
Sabatia kennedyana	Plymouth Gentian	NS	T/1984
Salix planifolia subsp. *tyrrellii*	Willow	Sask	T/1981
Scirpus verecundus	Few-flowered Club-rush	Ont	R/1986
Yucca glauca	Soapwort	Alta, Sask	R/1985

*E — endangered, T — threatened, R — rare, NIAC — Not In Any Category.
**Edited Status Report for marked species follow this subcommittee report.

preparation includes 389 species. As of April 1986, 35 species of vascular plants have been assigned COSEWIC status in Canada (Table 1). The largest number of these (23) are species whose range in Canada extends only, or at least in part, into Ontario. This preponderence of status reports for Ontario species is also seen in the listing of reports in preparation or under review (Table 2). This tends to reflect the relatively large number of rare Canadian peripheral species that occur in the province that are also known to be in jeopardy in the United States. Further updating of the candidates list will be made as new information becomes available.

Many populations of rare plants in southwestern Ontario are the remains of a previously more widespread Carolinian flora (species constituting the Deciduous Forest Region: Rowe 1972) that has become highly reduced and fragmented due to extensive land clearing for agriculture. The fact that a considerable number of Ontario species have had status designations assigned and reports completed reflects also the availability of local authors for report preparation as well as the increasing efforts of the Ontario Ministry of Natural Resources. Interestingly, the majority of reports for species in other provinces have also been written by Ontario authors.

A summary of the total number of plant status reports that have been completed or are in preparation by province of occurrence (with and without status designation) is as follows (this includes seven species that occur in more than one province): Alberta 2, British Columbia 8, Manitoba 2, New Brunswick 1, Nova Scotia 6, Ontario 34, Quebec 7, Saskatchewan 3. A greater participation of provincial government and non-government agencies and individuals at universities in the preparation of status reports would be most welcome; enquiries about preparation of individual reports should be addressed to the chairman of the Plants Subcommittee.

Publication of Plant Status Reports

With the publication of the first fish status reports in *The Canadian Field-Naturalist* (see Campbell 1984), a precedent has been set for the systematic publication of edited versions of status reports. Prior to this precedent, authors of plant status reports were encouraged to publish the results of their reports in journals of their choice; a few have published some of the data from their reports. The Plants Subcommittee now will follow the lead of the Fish and Marine Mammals Subcommittee and recommend that substantive accounts of status reports be published in *The Canadian Field-Naturalist*. Revised status report manuscripts should be submitted to the subcommittee chairman and should follow the format exemplified by the plant status reports accompanying this article.

Acknowledgments

The success that the Plants Subcommittee has had in contracting for status reports is due largely to the generous financial assistance of World Wildlife Fund Canada. The majority of reports that are in preparation or have been completed have been funded by this agency. The matching fund scheme, in particular, was invaluable in promoting the increased production of plant status reports for southwestern Ontario. The Canadian Wildlife Service has also funded a number of plant reports.

I would like to thank all those who have served or are now serving as members of the Plants Subcommittee: J. D. Ambrose, University of Guelph Arboretum; A. Bouchard, Institut Botanique, Montréal; L. Brouillet, Institut Botanique, Montréal; P. M. Catling, Biosystematics Research Centre,

TABLE 2. Plant status reports in preparation or under review.

Scientific Name	Common Name	Province
Camassia scilloides	Wild Hyacinth	Ont
Castanea dentata	Chestnut	Ont
Chimaphila maculata	Spotted Wintergreen	Ont
Cicuta maculata var. *victorinii*	Victorin's Water-hemlock	Que
Collinsia verna	Blue-eyed Mary	Ont
Desmodium illinoense	Illinois Tick-trefoil	Ont
Gentiana victorinii	Victorin's Gentian	Que
Hemicarpha micrantha	Common Hemicarpha	Ont
Hibiscus moscheutos	Swamp Rose-mallow	Ont
Liatris spicata	Dense Blazing-star	Ont
Limnanthes macounii	Macoun's Meadow-foam	BC
Liparis lilifolia	Large Twayblade	Ont
Morus rubra	Red Mulberry	Ont
Triphora trianthophora	Nodding Pogonia	Ont

Agriculture Canada, Ottawa; P. A. Keddy, Department of Biology, University of Ottawa; G. Straley, Botanical Garden, University of British Columbia; R. L. Taylor, Chicago Botanical Garden. Their critical review of reports has been of considerable help to the chairman in preparing the final copies for COSEWIC members prior to status designation.

Special thanks to G. W. Argus, the first chairman of the subcommittee, for the groundwork he laid in preparing the basic list of candidate species and the guidelines for authors preparing status reports, and to D. Muir, secretary for COSEWIC, for his assistance to me as present subcommittee chairman.

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Status of the Southern Maidenhair Fern, *Adiantum capillus-veneris* (Adiantaceae), in Canada*

Daniel F. Brunton

Southwick Drive, R.R. 3, Manotick, Ontario K0A 2N0

Brunton, Daniel F. 1986. Status of the Southern Maidenhair Fern, *Adiantum capillus-veneris* (Adiantaceae), in Canada. Canadian Field-Naturalist 100(3): 404–408.

The Southern Maidenhair Fern (*Adiantum capillus-veneris*) is known in Canada from a single station at Fairmont Hot Springs in the Columbia Valley of eastern British Columbia, where it was first noted a century ago. It is found along a single ledge of a tufa (calcium carbonate) rock-face at the edge of hot, mineral spring effluent. It was formerly abundant at the margins of hot spring runnels at this location, but has been severely reduced by the increasing containment of the hot water sources for diversion into the swimming pool of the adjacent resort. Only 68 fronds (all sterile) were found in 1982. The species is disjunct here, occurring about 1500 km north of its normal range. *Adiantum capillus-veneris* is endangered in Canada.

Key Words: *Adiantum capillus-veneris*, British Columbia, endangered, distribution, population size.

The Southern Maidenhair Fern, *Adiantum capillus-veneris* L., is one of only four species of the large cosmopolitan genus *Adiantum* found north of the tropics; it is also the type species of the genus (Tryon and Tryon 1982). This and other species of *Adiantum* are widely cultivated (Hoshizaki 1970) and can become "weedy" in greenhouse situations. It is a delicate, drooping, pale-green fern with widely-spaced, fan-shaped pinnules that are positioned alternately along the black rachis (Figure 1).

Distribution

Adiantum capillus-veneris is cosmopolitan, being found across the southern half of North America (more widely and commonly so in the west), throughout northern South America (where it is introduced) and across Eurasia (Hitchcock et al. 1969, Tryon and Tryon 1982). Its distribution in North America is given in Figure 2 (see the COSEWIC report for detailed references for this map). In Canada, it is known only from Fairmont Hot Springs in the Columbia Valley of southeastern British Columbia where it was first noted in 1888 and reported in the casual travelogue of the Dutchess of Somerset (Eastham 1949). Davidson (1916) provided the first authoritative Canadian reference, with supporting voucher specimens. Eastham (1949) reviewed the history of this species at the Fairmont site up to that date. It was found regularly there until the late 1950s but due to extensive enlargements to the resort facility in the 1960s, it was widely thought to have been extirpated. J. D. Lafontaine rediscovered the species at Fairmont Hot Springs at its present site in 1974. Although Taylor (1963) reported a collection of *A. capillus-veneris* from Salt Spring Island off Vancouver Island, I could find no supporting voucher for it. In view of its omission from his subsequent treatment of the pteridophytes of this region (Taylor 1970), the Saltspring Island record probably represents a misidentification.

Habitat

In its normal range, *A. capillus-veneris* occurs on shaded, moist, rocky sites on porous, calcareous rock, including tufa (calcium carbonate rock that forms from the precipitate of hot, mineral-rich spring water), masonry and other soft, limy rocks (Wherry 1978). Hoshizaki (1970) states that while *A. capillus-veneris* can survive winter temperatures to −2°C, it is killed at temperatures below −18°C.

The Canadian population grows at the very edge of open channels of very hot (48.9°C), mineral-rich spring water (McDonald et al. 1981) on a low tufa wall (1.8 m high) in a sheltered trench. This trench was excavated about 1911 to permit construction of a stone bath-house which is still (informally) used (Figure 3). Water from a leak in the pipe conducting hot spring water to the modern resort facilities 200 m away spills over the lip of the trench and creates a continuously very warm, very humid microclimate. *Adiantum capillus-veneris* grows here with few other vascular plant species. One of these is the threatened *Epipactis gigantea* (COSEWIC status assigned 4 April 1984). At Fairmont Hot Springs, the Southern Maidenhair Fern has never been observed more than a few decimeters away from running hot water.

*Based on a COSEWIC status report by the author. Copies of the complete report are available at cost from the Canadian Nature Federation, 75 Albert St., Suite 203, Ottawa K1P 6G1. Endangered status approved and assigned by COSEWIC, 4 April 1984.

FIGURE 1. Fronds of Southern Maidenhair Fern (*Adiantum capillus-veneris*) at Fairmont Hot Springs, British Columbia (22 July 1982).

General Biology

Adiantum capillus-veneris reproduces from spores as well as vegetatively from new fronds arising along the horizontally creeping rhizomes. Its spread by vegetative means can be relatively rapid, with plants covering areas of about 2 m^2 in less than 15 years (personal observation). The colonization of such sites at the old bath-house at Fairmont Hot Springs and on old limestone walls in more temperate regions (cf. Wherry 1978) indicates that local aerial dispersal of spores is a viable and effective means of dispersal for the species. The presence of Southern Maidenhair Fern at sites far disjunct from its normal range, such as in the Black Hills of South Dakota (at a hot spring) and in southern British Columbia, indicates that long-distance dispersal (presumably by spores) has probably also occurred.

The British Columbia population of *A. capillus-veneris* is completely sterile at present, reproducing only vegetatively. However, as recently as 1977, I had collected fertile fronds at this locality.

Population Size and Trends

Adiantum capillus-veneris occurs in small (and declining) numbers in Canada. In July 1982 I counted a total of 68 fronds (all sterile) growing along a single, 40 cm long section of ledge. That represented a significant decline from the virtually continuous growth of fertile fronds seen on two parallel ledges along 1 m of the rock face in 1977 (personal observation). A similarly dense growth, over 3 m in extent by 20 cm high, was observed by J. D. Lafontaine in 1974. Frond size has also been reduced significantly from that of material collected prior to 1960 when it was abundant at the original site.

Limiting Factors

Adiantum capillus-veneris requires a very precisely defined habitat — a very humid, continuously warm microclimate, on a porous, highly calcareous substrate. Such habitats are rare in Canada (McDonald et al. 1981). The Southern Maidenhair Fern seems to be intolerant of competition from other vascular plants (Wherry 1978; Hoshizaki 1970; personal observations). The continued formation of bare rock face at the hot springs by tufa precipitation from the mineral springs water may allow this rapid colonizer to escape competing vascular plants.

The effects of disease and predation have not been observed and hybridization is unknown in the genus *Adiantum* (Hoshizaki 1970).

The continued survival of *A. capillus-veneris* at

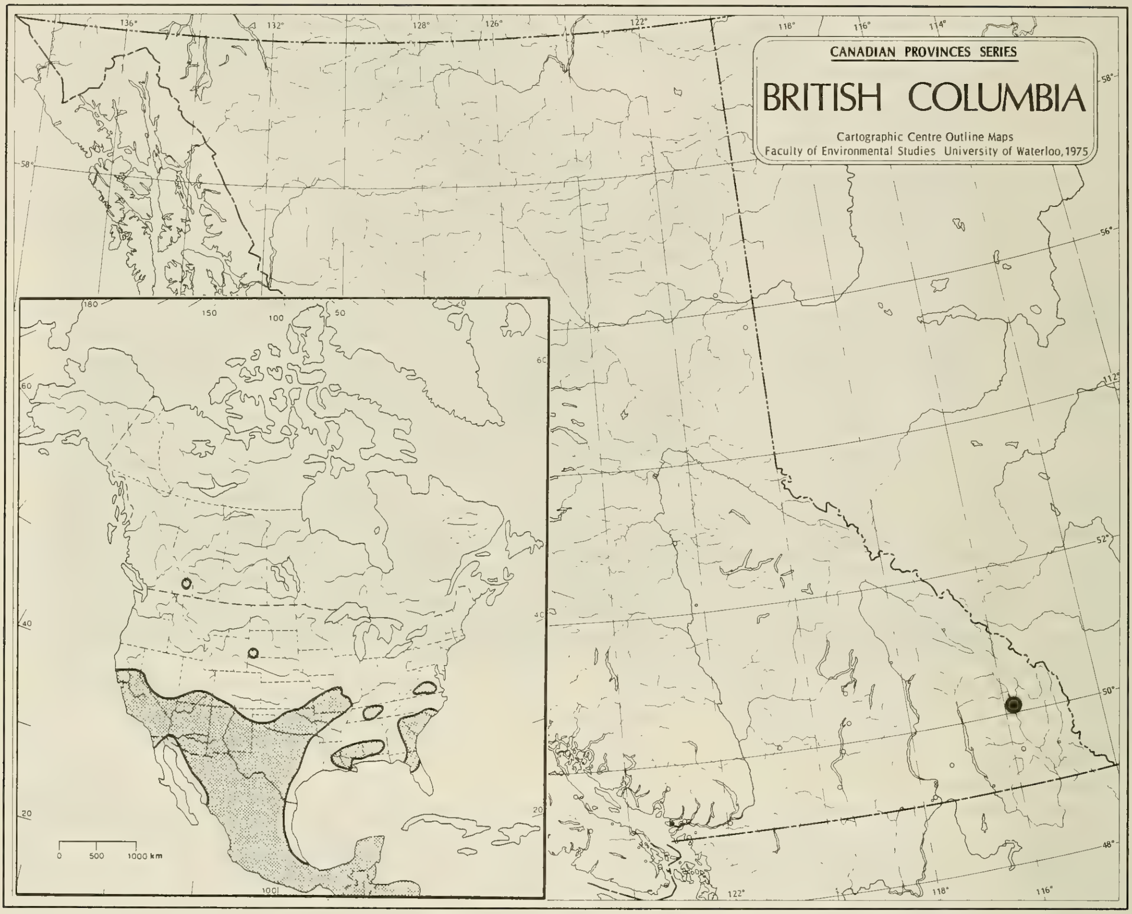

FIGURE 2. The distribution of Southern Maidenhair Fern (*Adiantum capillus-veneris*) in British Columbia and North America (insert).

Fairmont Hot Springs requires, as a minimum, a continuous flow of hot mineral spring water at the old bath-house site. These natural ("wild") sources are all but completely enclosed in plastic pipes at the Fairmont Hot Springs Resort; it is upon the incidental leakage from one of these pipes that the Southern Maidenhair Fern presently depends for its continued, tenuous existence. I was informed by the resort manager that the few remaining "wild" spring sources would also be contained within pipelines in the future. Although *Adiantum capillus-veneris* can apparently withstand physical alteration to its growing site (short of complete destruction), alterations to its humid, continuously warm microclimate are fatal. Although major developments in the 1960s undoubtedly destroyed many of the plants at the original site, its permanent elimination there was more likely the result of the diversion of "wild" hot water sources through pipes into the swimming pools. The effluent from these pools now is lukewarm (personal observation).

After almost 70 years of collecting at the Fairmont Hot Springs site, there are many vouchers in Canadian herbaria (DAO, UBC, VIC, CAN, DFB, UAC — acronyms follow Boivin 1980). Most of these specimens pre-date 1960, when the species was abundant at the site, so their removal had little or no detrimental impact. The species is so rare now that any further collecting at the Fairmont stand (especially if such collections included rhizomes) could constitute a serious blow to its chances of survival. The abundance of material from this station

FIGURE 3. Site of Southern Maidenhair Fern (*Adiantum capillus-veneris*) at Fairmont Hot Springs, British Columbia. The fern is on the tufa wall, as indicated by the arrow. The lighter area to the right (*) represents recent tufa formation (22 July 1982).

in herbaria across Canada renders any further collections at the site unnecessary and exploitive.

Special Significance of the Species

The Southern Maidenhair Fern is a good example of a species that has become established by long-range dispersal. As a species with special substrate and microclimatic preferences it also offers the potential for research into the phenomenon of habitat specificity.

Protection

Adiantum capillus-veneris is listed as Rare in Canada in Kershaw and Morton (1976) and as Rare (R1 — a few populations) in British Columbia in Straley et al. (1985). It is also considered rare in Colorado (W. I. Weber and B. C. Johnston 1976. Natural history inventory of Colorado. 1. Vascular plants, lichens and bryophytes. Unpublished report, University of Colorado, Boulder). None of these designations, however, provide any legal protection for the species or its critical habitat. It is relatively common throughout much of its range, and has not required protection in most regions.

Evaluation of Status

Adiantum capillus-veneris is considered endangered in Canada because of its occurrence at a single locality at which it has experienced a dramatic decline in numbers and because of the threat to the remaining source of hot mineral water that presently maintains its microclimate. The species faces extirpation within the next few years if mitigative measures are not undertaken soon.

Acknowledgments

My thanks to J. D. Lafontaine, Biosystematics Research Institute, Ottawa, for sharing his observations and data with me. My thanks too, to G. W. Argus, National Museum of Natural Sciences, Ottawa, for assistance in securing important literature and for making the necessary administrative arrangements for the original COSEWIC study. An earlier draft of the manuscript benefited significantly from the critical review of E. Haber, chairman of the COSEWIC Subcommittee for Plants and my thanks to him for his efforts. The original COSEWIC study was conducted with the assistance of funds from World Wildlife Fund (Canada).

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Status of the Mosquito Fern, *Azolla mexicana* (Salviniaceae), in Canada*

DANIEL F. BRUNTON

Southwick Drive, R.R. 3, Manotick, Ontario K0A 2N0

Brunton, Daniel F. 1986. Status of the Mosquito Fern, *Azolla mexicana* (Salviniaceae), in Canada. Canadian Field-Naturalist 100(3): 409–413.

The Mosquito Fern, *Azolla mexicana*, is known in Canada from four stations near Shuswap Lake in southern British Columbia. It has persisted at two of these stations for almost a century. It is an aquatic species, occurring free-floating or anchored to emergent vegetation or the shoreline. It is most common in shallow, quiet water where it can reproduce at a rapid rate and may completely cover all areas of open water. *Azolla mexicana* grows symbiotically with the blue-green alga *Anabaena azollae*, which has tremendous nitrogen-fixing capacity. This enables *Azolla* to grow in nutrient-poor, somewhat acidic water. *Azolla mexicana* is very sensitive to salt, oil and herbicides. Three of the Canadian stations are vulnerable to destruction from accidental chemical spills from adjacent highway and/or railway traffic. The other station, away from major transportation routes, has not been examined since its discovery 10 years ago. *Azolla mexicana* is threatened in Canada.

Key Words: *Azolla mexicana*, British Columbia, threatened, distribution, population size.

The Mosquito Fern, *Azolla mexicana* Presl. (= *A. caroliniana* sensu Macoun 1890), is a member of a small genus of very similar aquatic pteridophytes. Members of the genus occur in both the Old and New Worlds and are found mostly in more southern areas with milder climates (Tryon and Tryon 1982). *Azolla* is taxonomically a very difficult genus and has been variously described as consisting of one species (e.g. Deam 1940; Davis 1952), two species (e.g. Kearney et al. 1960) or three species (Svenson 1944; Tryon and Tryon 1982) in North America. This latter concept appears to have good morphological and phytogeographic support and is followed in this study. Even in the broadest sense, however, *Azolla* is very restricted in Canada. Beyond the records identified in this study, it is known in Canada only from 19th century reports of *A. caroliniana* from Ontario (Macoun 1890).

The Mosquito Fern has considerable economic importance in some parts of the world. It was cultivated as a natural fertilizer in rice paddies in Vietnam for many years, although the social upheavals in that nation in the 1960s and 1970s leave the status of this practice unclear. It has also been used in Asia as a livestock fodder and as a remedy for sore throats in New Zealand. It serves as an aquatic weed and mosquito control tool in Asia, and as a constituent of soap in parts of Africa (Lumpkin and Plunknett 1980).

Azolla mexicana is a tiny, finely-divided plant that floats on the surface of ponds and quiet water, forming huge populations that may eventually completely cover the surface (Figures 1 and 2). By late summer and early fall, cool nights trigger the production of anthocyanins, which give the fern a very distinctive brick-red colour (Taylor 1970; Cranfill 1980).

Distribution

Figure 3 illustrates the Canadian and North American distribution of *A. mexicana* (see COSEWIC report for detailed references to this map). The large range gaps approximately match the distribution of saline soils in the semi-arid and arid portions of its overall range (Patterson 1970). It was first collected in Canada on 17 July 1889 by John Macoun at Sicamous, British Columbia (CAN; see below). He subsequently reported this site, and another nearby station at Salmon Arm, in his *Catalogue of Canadian Plants* (1890). No new collections were made until James A. Calder and colleagues discovered a new station near Cambie, northeast of Sicamous. Since then, *A. mexicana* has been collected regularly at Cambie (though not exactly at the Calder site). An additional site, north of Sicamous, was found by C. Brayshaw in 1974. The two sites reported in Macoun (1890) were rediscovered during this study.

Habitat

The Canadian stations occur in quiet backwaters and/or in ox-bow lakes over sandy flood plain deposits. These sites are usually surrounded by young

*Based on a COSEWIC status report by the author. Copies of the complete report are available at cost from the Canadian Nature Federation, Suite 203, 75 Albert Street, Ottawa K1P 6G1. Threatened status was approved and assigned by COSEWIC on 4 April 1984.

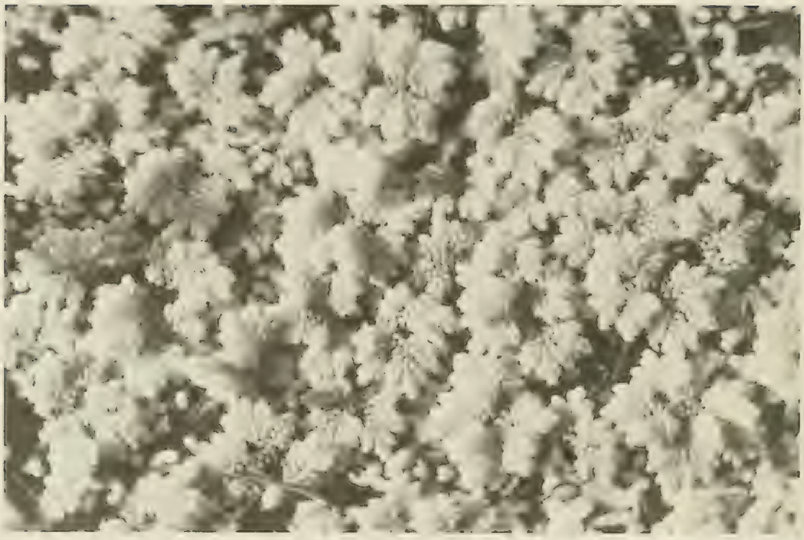

FIGURE 1. *Azolla mexicana* growing in a pool with *Lemna minor* (21 July 1982, Salmon Arm, British Columbia).

FIGURE 2. Expanding clusters of *Azolla mexicana* on pool surface (21 July 1982, Sicamous, British Columbia).

hardwood and/or mixed forests. The plants are both free-floating and anchored to emergent logs, rotting vegetation or the shoreline. A dramatically reduced water level is apparently important for the development of *A. mexicana*. Lumpkin and Plunknett (1980) note that optimum growth results in somewhat acidic, salt-free water.

General Biology

A blue-green alga, *Anabaena azollae*, grows in cavities on the upper surfaces of all *Azolla* species and is a nitrogen-fixing agent. Its capacity is enormous and may be equivalent to that of legumes (Tryon and Tryon 1982). This nitrogen-fixing ability permits *Azolla* to grow in nutrient-poor water and is likely an

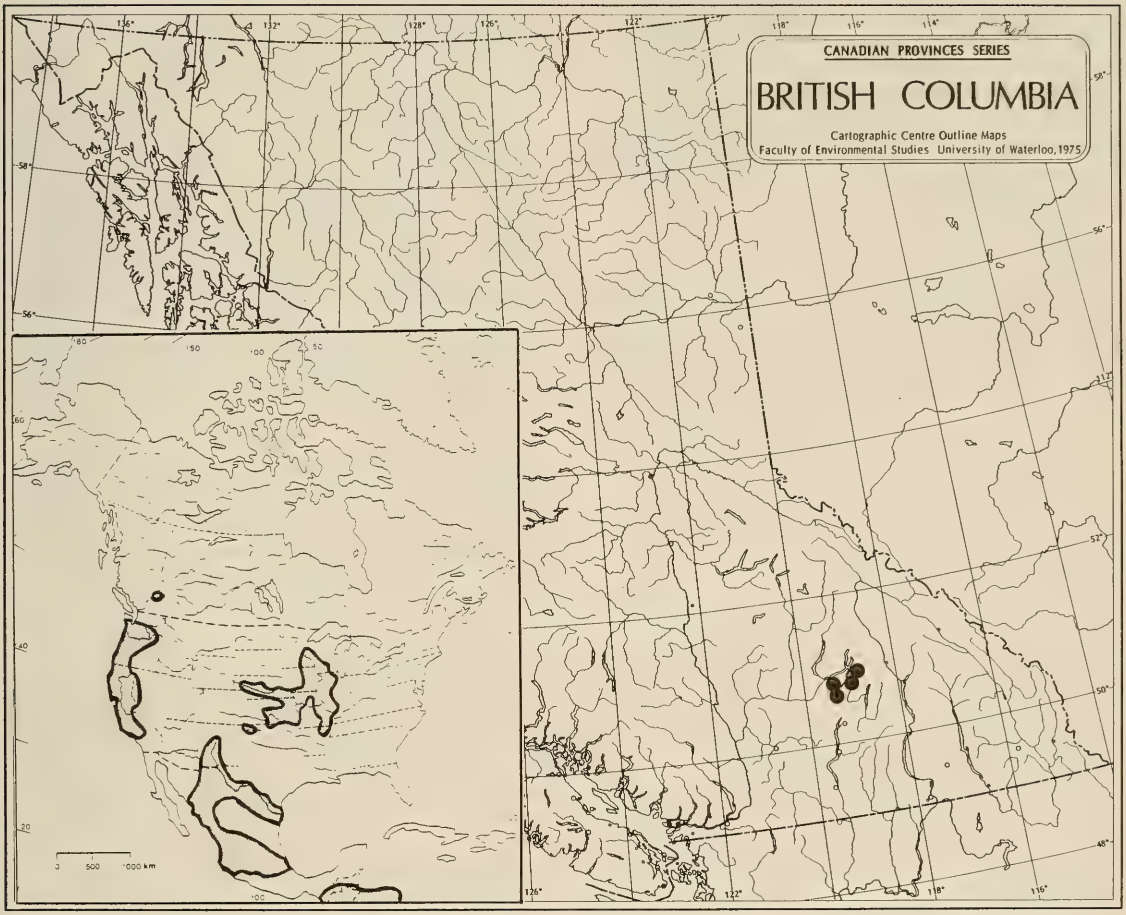

FIGURE 3. Distribution of *Azolla mexicana* in British Columbia and North America (inset).

important competitive advantage against other species of aquatic plants.

Individual plants are annual, completely disappearing each fall. A rain of sporocarps containing either microspores or megaspores descend to the bottom at this time. When the conditions are again suitable in the next (or some subsequent) growing season, the spores float to the surface of the water. The relatively few megaspores and more numerous microspores germinate, and after the fusion of gametes, small sporophytes are produced. These relatively few floating plants reproduce vegetatively at an explosive rate, filling in all available growing space. The factors that trigger this growth are unknown but appear to include declining water levels and various chemical changes.

Population Size and Trends

Within the narrow confines of the *Azolla* stations themselves, the species is abundant. An estimate of 13.5 million plants developed during the COSEWIC study, but for a species which grows in small, very dense stands of numerous tiny individuals, that figure is deceptive. The areal size of *Azolla* stations is a better indicator of real abundance. This would be Sicamous station, 15×15 m (225 m^2); Salmon Arm station, 100×5 m (500 m^2); Cambie station, 125×30 m (3750 m^2); Tappen station, unknown. There is very little information on the Tappen site ; it has not been examined since its discovery in 1974.

The Cambie and Salmon Arm stations are relatively large, healthy and stable. The Sicamous station, however, has definitely declined. Macoun

(1890) describes it as "... very abundant ... in pools along the C. P. Ry. between the bridge at Salmon Arm and the first crossing of the Eagle River...". In 1982, I found it only in one pond here (an ox-bow that has been dissected by the Trans-Canada Highway). It was apparent only in the southern section of this pond, perhaps having been destroyed by water pollution in the northern portion.

Limiting Factors

Azolla mexicana may well be dependent on the nitrogen-fixing ability of its associated blue-green alga for survival in nutrient-poor water. This ability is most pronounced in low light conditions and cannot occur without a source of manganese available to the alga (Lumpkin and Plunknett 1980). These authors state that nitrogen-fixation is optimized at low (4.5 to 7.0) pH associated with indirect sunlight (50% of full light). The Sicamous station (under partial shade) had a pH of 6.5, while the Salmon Arm station (in full sunlight) was 8.1; the latter is beyond the optimum range for *Azolla* development.

Azolla cannot tolerate high salt levels, and the accumulation of roadway de-icing salts at the roadside sites may be adversely affecting some populations. High conductivity readings in water samples taken in July 1982 at the Sicamous and Salmon Arm stations (169 and 500, respectively) may indicate a rather high salt load already.

Past infilling of habitat has damaged the Sicamous station and could easily damage the others. The roadside stations are most vulnerable to road construction and to chemical pollution that could result from traffic accidents. Lumpkin and Plunknett (1980) state that *Azolla* is quickly killed by petroleum products and some herbicides (including 2,4-D, Paraquat and Diquat). Similar threats are presented to the Salmon Arm station by the potential of accidents along the railway line which runs through it. The Tappen site is, apparently, free of such threats but its situation and status are unclear.

On the basis of visual surveys, there would appear to be many areas of unoccupied suitable habitat in the Shuswap region and elsewhere in southern British Columbia. Despite searches in such areas during (and previous to) this study, no new stands were found. Some subtle and obscure aspects of the habitat and/or ecology of the species (e.g. dispersal mechanisms, water chemistry and water-level fluctuation history) are apparently missing at these sites.

Insect predators on *Azolla* have been identified by Lumpkin and Plunknett (1980), but none were observed on Canadian plants. There is also no evidence to suggest that horticultural collecting or the collection of scientific vouchers (housed in DAO, CAN, UBC, VIC, UAC and DFB - acronyms of Boivin 1980) have had any negative impact.

Special Significance of the Species

Azolla mexicana is the only Canadian representative of the family Salviniaceae. Its sensitivity to small quantities of chemical pollutants may serve as a useful indicator of water pollution in some areas. The significance of *Azolla* an an economic crop, for fertilizer, fodder and other uses, has been well established and is under continuing investigation (Cranfill 1980). The characteristics of the symbiotic relationship between *Azolla* and the alga *Anabaena azollae* may also prove to be a fruitful subject of scientific investigation.

Protection

Azolla mexicana is listed as Rare (R1 — a few populations) in British Columbia by Straley et al. (1985). This designation provides no legal protection for the species or for its critical habitat. There are no protective regulations applying to *A. mexicana* in Canada at present.

Evaluation of Status

Azolla mexicana is considered to be threatened in Canada. One of its four stations is poorly known and has not been examined since its discovery 10 years ago. The other three are adjacent to major transportation corridors and are vulnerable to accidental spills of toxic chemicals and to the negative effects of salt pollution from roadway de-icing programs. One site has been reduced significantly by road construction. The species is apparently capable of maintaining itself at these sites if the habitat does not degrade further.

Acknowledgments

My thanks to K. L. McIntosh of Ottawa for her assistance with the field work undertaken during the COSEWIC study and to J. D. Lafontaine of Agriculture Canada, Ottawa and H. L. Dickson of the Canadian Wildlife Service, Edmonton, for data, photographs and specimens of *Azolla* in Canada. I appreciate the assistance provided by G. W. Argus and C. Keddy of the National Museum of Natural Sciences in obtaining literature during the COSEWIC study. P. M. Catling of Biosystematics Research Centre, Agriculture Canada, Ottawa, facilitated the analysis of water samples from the study sites and the curators of the vascular plant herbaria at the National Museum of Natural Sciences, Ottawa, Agriculture Canada, Ottawa, the University of British Columbia, Vancouver, the Provincial Museum of British Columbia, Victoria and the University of Calgary,

Calgary, permitted access to their collections. The COSEWIC study was supported in part by a financial contribution from the Environmental Conservation Service of Environment Canada.

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Status of the Giant Helleborine, *Epipactis gigantea* (Orchidaceae), in Canada*

DANIEL F. BRUNTON

Southwick Drive, R.R. 3, Manotick, Ontario K0A 2N0

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The Giant Helleborine, *Epipactis gigantea*, is known in Canada from 12 sites in southern British Columbia, the earliest of which was discovered in 1877. It grows in open, wet sites adjacent to mineral springs (including hot springs) on calcareous, porous substrates. Most of the Canadian stations are known from single records and only four have been seen since 1965. The largest known extant station, at Fairmont Hot Springs, has declined in recent years and is vulnerable to further site disturbance. *Epipactis gigantea* is threatened in Canada.

Key Words: *Epipactis gigantea*, Giant Helleborine, British Columbia, threatened, distribution, population size.

The Giant Helleborine, *Epipactis gigantea* Douglas ex Hooker, is a member of a small genus of about 20 species of the temperate regions of Eurasia and North America (Luer 1975). It is one of only two North American species, the other being the introduced *E. helleborine*, the Helleborine, of Europe that has become a widespread "weed" in northeastern North America and in southwestern British Columbia (Scoggan 1978; Brunton 1986a). There is no evidence of *E. gigantea* spreading in the aggressive manner of *E. helleborine* although it has been successfully transplanted from the wild into gardens in Canada. It is not known to have medicinal or economic uses.

Epipactis gigantea is a leafy, erect orchid, standing 20–70 cm tall and with 3–5 showy flowers aligned along one side of the upper stem. The flowers are coppery-green in colour, with sepals and petals striped with brown and brownish-purple. Each flower has a prominently raised sac that is distinctly marked with thin purple streaks (Figure 1). The plant is found growing in both small and large groups, usually occurring in dense stands (Figure 2).

Distribution

Epipactis gigantea extends from central Mexico northward throughout the western United States and into southern British Columbia. Its range is completely within cordilleran areas of the continent (Figure 3; see the COSEWIC report for detailed references to this map). It was first collected in Canada along the international border at Osoyoos, British Columbia, by George Dawson on 18 June 1877 (Macoun 1890). By 1900, two other stations, now extirpated, had been found in Canada. Additional stations were occasionally discovered thereafter. None of these are located north of Shuswap Lake (ca. 51°N latitude) and only one old station is known within 200 km of the Pacific Ocean. Most stations are found in the dry interior of southern British Columbia (Figure 3).

FIGURE 1. Flower of *Epipactis gigantea*; note the Snout Beetle (Curculionidae) on the back of the flower (22 July 1982, Fairmont Hot Springs, British Columbia).

*Based on a COSEWIC status report by the author. Copies of the complete report are available at cost from the Canadian Nature Federation, Suite 203, 75 Albert Street, Ottawa K1P 6G1. Threatened status was approved and assigned by COSEWIC on 4 April 1984.

FIGURE 2. Dense cluster of *Epipactis gigantea* (22 July 1982, Fairmont Hot Springs, British Columbia).

Habitat

Epipactis gigantea grows locally on open, sunny seepage slopes and rocky stream banks. In the northern portion of its range, it prefers the margins of hot springs (Luer 1975). The Canadian stations all appear to be in protected sites at the edge of running water. The largest known Canadian station is found along the margins of hot spring runnels. The substrate at Canadian sites is calcareous, and is often composed of porous, exposed tufa or limestone bedrock.

General Biology

This species is usually found growing in thin, partially decomposed, wet, organic substrate. It is rarely reported in forested sites, being a species of open, early successional habitats. It can colonize suitable habitats quickly; a large stand at Fairmont Hot Springs, for example, has spread across a mat of Creeping Juniper (*Juniperus horizontalis*) that had overgrown recent human artifacts, such as glass bottles.

Epipactis gigantea reproduces from microscopically small, aerially dispersed seed. It also reproduces vegetatively from shoots off the rhizome. There is evidence for both reproductive means at Fairmont Hot Springs. The mechanism for pollination of *E. gigantea* are not clearly understood, though Luer (1975) states that pollination is by syrphid flies. I observed a small Snout Beetle (Curculionidae) crawling in and around a particular flower for several minutes (Figure 1) but I did not observe it on the pollinia. Autogamy is known in *E. helleborine*, by rotation of the pollinia against the stigmatic surface and by pollen grains falling on to the stigma (Catling 1983). It is not known for *E. gigantea*.

This species is a perennial herb in which the above-ground parts completely wither each fall. Because only a few flowers bloom at one time along the flower spike, *E. gigantea* has a long blooming period, extending (in British Columbia) from at least mid-June until mid-August. Peak flowering appears to be in mid-July.

Population size and trends

Twelve locations for *E. gigantea* are known in southern British Columbia, all within 300 km of the United States border. Three sites (Radium Hot Springs, the Arrow Lakes and north of Kootenay Lake) have been destroyed by development. Two others (Osoyoos [1877] and Ainsworth [1890]) have not been observed for many years (despite subsequent studies in these areas) and are probably extirpated. The station at Cultus Lake, Chilliwack, was known throughout the 1920s and into the 1930s. It has not been documented since and is probably gone as well. Of the remaining six stations, those at Agate Bay on Lake Okanagan, at Enderby and at Boswell, have not been recorded for at least 30 years; their status is uncertain.

Four stations are known from post-1965 collections. They are at Naramata, at Sicamous, at Celista on Shuswap Lake and at Fairmont Hot Springs. *Epipactis* has been known at Fairmont Hot Springs since 1922, although the sites at this location where collections were made prior to 1970 have been destroyed by development. The size of the populations at the other modern stations is unknown, but at Fairmont Hot Springs, over 230 plants were observed in July 1982. All were on one open tufa slope.

Only a small number of *Epipactis* sites have been known at any one time in Canada. Most stations (nine of the twelve) are known only from single records. The largest site, at Fairmont Hot Springs, has been reduced by resort expansion, and the remaining plants are threatened by the diversion of the hot mineral water in which they are growing and by possible further development.

The widespread distribution of stations suggest that

FIGURE 3. Distribution of *Epipactis gigantea* in British Columbia and North America (insert).

others may be found within the Canadian range of *E. gigantea*. An examination of the many hot spring sites in British Columbia (McDonald et al. 1981) would be a likely first step in any such search. At present, however, the known population of *E. gigantea* is small and declining in Canada.

Limiting Factors

The existence of a continuing supply of hot mineral water appears to be important to the large Fairmont Hot Springs population, as no plants were found there away from open hot spring sources. Its apparent ability to grow in sizeable numbers only in open, spring-fed, calcareous sites with little associated vegetation may indicate a poor competitive capacity.

Physical developments, such as hydro-electric dams, agriculture, and resort expansion, have destroyed a number of stations in the past and remain a threat to the scattered, localized stands of *E. gigantea* that are known today.

The effects of insect predation and disease on this species are unknown. Whereas transplantation of plants into gardens could be a serious threat to Canadian populations, to date it has only been documented at Cultus Lake (where *Epipactis gigantea* apparently no longer grows). The collection of botanical voucher specimens (maintained in the VIC, UBC, DAO, CAN, UAC and DFB herbaria — acronyms of Boivin 1980) does not appear to have had a significant impact on Canadian stations, although the potential for serious damage is present.

Special Significance of the Species

Epipactis gigantea is the only native member of its genus in Canada and the United States. Studies of its particular habitat requirements may provide insight

into the distributional limitations of this species and some of the other significant taxa with which it grows (e.g. *Panicum thermale, Adiantum capillus-veneris*: Brunton 1986b; Scoggan 1978). The pollination mechanisms utilized by *Epipactis gigantea* are unknown and could offer worthwhile topics for pollination biology research.

Protection

Epipactis gigantea is protected from international trade under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (Argus 1978). It is listed as Rare (R-4, restricted distribution, large populations) in British Columbia (Straley et al. 1985) and Rare in Colorado (Weber and Johnson 1976). It is described as a *Sensitive* species in Washington (not *Threatened* or *Endangered*; Anonymous 1981). None of these provincial or state designations provide any protection for the species or its critical habitat, however.

Evaluation of Status

Epipactis gigantea is considered to be threatened in Canada because it has been recorded only in a small number of locations, most of which have not been seen for many years. Only one of our modern stations is known from more than a single record. This station, at Fairmont Hot Springs, has declined significantly in recent years and is threatened by adjacent development activities. Unless new stations are found and/or the critical habitat at the few known stations can be maintained, *Epipactis gigantea* may become endangered in Canada.

Acknowledgments

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Agriculture Canada Research Branch Centennial 1886-1986

WILLIAM J. CODY

Biosystematics Research Centre, Agriculture Canada, Ottawa, Ontario K1A 0C6

On 2 June 1886, *The Experimental Farm Station Act* received Royal Assent. The passage of this legislation by Canada's parliament allowed the creation of the first five experimental farms at Nappan, Nova Scotia; Ottawa, Ontario; Brandon, Manitoba; Indian Head, Saskatchewan (then the North-West Territories); and Agassiz, British Columbia. Today's over forty establishments, which span the country from St. John's West, Newfoundland to Saanichton, British Columbia, have grown from this modest beginning.

The original experimental farms were established to serve the farming community and to assist the Canadian agricultural industry during its early development. With the changing times what is now the Research Branch of Agriculture Canada continues to search for new technology that will ensure the development and maintenance of a competitive agri-food industry. Thus research programs centre on soil management, crop and animal productivity protection and resource utilization, biotechnology, and food processing and quality. A history of these activities has been written by T.H. Anstey (1986) and separate histories have been written for a number of individual establishments.

Members of The Ottawa Field-Naturalists' Club and readers of *The Canadian Field-Naturalist* will perhaps be most interested in the activities that have centered around the entomological, vascular plant and mycological collections of the department which now form a part of the Biosystematics Research Centre. Cody et al. (1986) have written a history of systematics in Agriculture Canada at Ottawa that tells of the development of these collections and the individuals who have worked with and contributed to them, together with other related information.

The Canadian government involvement in botany and entomology had parellel beginnings with the appointment of one individual. This was James Fletcher. Fletcher, a young Englishman in the employ of The Bank of British North America, was posted to Canada from London in 1874. After two years he resigned from the bank to join the Library of Parliament as an accountant. In the following years he developed a considerable interest in natural history, and in particular, botany and entomology. As a result of this interest, he was named honorary entomologist in the Dominion Department of Agriculture in 1884, but he retained his position in the Library of Parliament.

When the Experimental Farms Branch was organized in 1886, William Saunders, who was a distinguished pioneer entomologist, was named its first director. An order-in-council dated 18 July 1886, sponsored by the Minister of Agriculture, recommended that "James Fletcher, age 35, at present in the Office of the Library of Parliament, and acting since 1884 as Honorary Dominion Entomologist, be appointed to fill such joint position [entomologist and botanist]."

James Fletcher was one of the founding members of The Ottawa Field-Naturalists' Club. He was a most active member and its second president. Among his publications was a series entitled *Flora Ottawaensis* (Boivin and Cody 1955) which was published in *The Ottawa Naturalist*, predecessor of *The Canadian Field-Naturalist*.

Fletcher joined the department as Dominion Botanist and Entomologist in 1886. In his first report which he addressed to his director, Prof. W. Saunders, he wrote in part as follows ". . . During the past autumn efforts were made to gather together from the woods and fields in this locality, as large a collection as possible of the roots of our native plants. These were carefully removed and placed in nursery rows preparatory to such time as arrangements can be made for their permanent location in the Botanic garden. Large quantities of seeds of our local forest trees were collected and planted in the autumn, as well as others received from different parts of the Dominion. . ."

"Particular attention will be paid to the examination and cultivation of our native grasses. Many of the seeds collected by yourself in the North-West Territories last year, from apparently desirable species, are already planted, and give promise of satisfactory results. . ."

"In addition to the above, reference collections of preserved entomological and botanical specimens will of course be necessary for the advantageous

PLATE 1. This portrait of James Fletcher (1852-1908) was commissioned in 1910 by The Ottawa Field-Naturalists' Club, for whose existence he was largely responsible. Donated in 1929 to the Central Experimental Farm where Fletcher had been entomologist and botanist from 1887 to his death, it was accepted by the National Museums of Canada for care pending a suitable location for its installation. Fifty-five years later the portrait was reconditioned by the National Museum of Natural Sciences and returned to the farm on 2 June 1986, the centennial of its formation. The portrait is on permanent loan from the National Museum of Natural Sciences.

PLATE 2. Fletcher memorial fountain at the Central Experimental Farm, Ottawa.

prosecution of entomological and botanical work. Temporary cases have already been provided for the former, and no effort will be wanting on my part to build up, with all expedition, a collection, showing the injurious and beneficial insects which affect our crops."

"The value of having an extensive collection of our indigenous Canadian plants is easily apparent... To further this end, which I consider one of great importance, I have much pleasure in presenting to the farm museum my own Herbarium, comprising upwards of 3,000 species, collected in Canada mainly by myself."

"I beg also to announce that Dr. Selwyn, the Director of the Geological and Natural History Survey, has kindly given Prof. Macoun permission to fill up many of the deficiencies from the duplicates of his own vast collections in the National Museum, as soon as our museum is built and we are in a position to receive and preserve the specimens."

In this report, Fletcher also mentioned his interest in fungal diseases and their control, and indeed he was already well informed on the major crop diseases and their pathogens.

When James Fletcher died at the early age of 55 in November of 1908 he left behind him a well-laid foundation for botany and entomology in Canada. In a memorial issue of *The Ottawa Naturalist* (22(10): 189–234 [1909]) there were many tributes paid to him by his colleagues and in 1910 The Ottawa Field-Naturalists' Club commissioned an oil painting of him (Plate 1). In addition, the Club had a memorial fountain erected near the Macoun gardens on the Central Experimental Farm (Plate 2) (*Ottawa Naturalist* 24(5): 81–86 [1910].).

The collections grew slowly during their early years.

Actually the mycological herbarium did not come into being until after the appointment of Hans Theodore Güssow as Dominion Botanist in 1909. This was the date that marked the inception of the Division of Botany as an independent unit separate from entomology. The mycological herbarium officially became national only in 1932, but its formative roots were firmly in Plant Pathology.

In 1916, following the burning of the Houses of Parliament, the Victoria Museum building was taken over by Parliament. Because of the resulting congestion, the museum's collection of insects was transferred in 1917 to the Department of Agriculture. The Canadian National Collection of Insects was formed by the union of the collection of the Entomology Branch, Department of Agriculture, and that of the Biological Division of the Geological Survey, Department of Mines, and has remained the responsibility of the Department of Agriculture since that time.

All three collections grew slowly for many years, partly because the staff was small, but also because of the depression of the thirties which was followed by the second world war. After the war there was a great surge in activity. New and younger staff members began surveys in all parts of the country and in related regions elsewhere. From these surveys came many specimens that greatly enhanced the collections. The Vascular Plant Herbarium now numbers nearly 800 000 specimens. The National Mycological Herbarium contains nearly 250 000 specimens and the Canadian National Collection of Insects has over 13 000 000 specimens.

While all the time being parts of the Department of Agriculture, the establishments in which these collections were located have changed their names. Thus following Fletcher's death, C. G. Hewitt became Chief of the Entomology Division, with succeeding chiefs A. Gibson, H. G. M. Crawford, R. Glen, B. M. Smallman, G. P. Holland; H. T. Güssow became Chief of the Botany and Plant Pathology Division, with succeeding chiefs, J. H. Craigie and W. F. Hanna. In 1950, the latter division recognized three sections at its Ottawa headquarters: Botany, Mycology and Plant Pathology. With the amalgamation of the Experimental Farm Service and Science Service in 1959, the Mycological and Vascular Plant Herbaria came under the Plant Research Institute with H.A. Senn as its first Director. He was succeeded by A. P. Chan. G. P. Holland was the first director of the Entomology Research Institute. He was followed by W.B. Mountain who in turn was succeeded by D. F. Hardwick. Another change came in 1973 when the Plant Research Institute and Entomology Research Institute were amalgamated to form the Biosystematics Research Institute under the directorship of D. F. Hardwick. Finally entomologists, botanists and mycologists were back together again in a single organization, although not under the same roof. G. A. Mulligan became director of this institute in 1978. Now in the Centennial Year the name has changed again — to Biosystematics Research Centre.

Through all these changes a solid group of botanists, mycologists and entomologists have studied the vascular plant and fungal flora and insect fauna of Canada and related regions. They have been prolific in their writings. Some examples of their efforts are *The Farm Weeds of Canada* (1906, 1909), *Principal Poisonous Plants of Canada* (1920), *Grasses of Ontario* (1980), *Plants of Prince Edward Island* (1960), *Flora of the Prairie Provinces* (1967-1981), *The Flora of the Queen Charlotte Islands* (1968), the *Biology of Canadian Weeds* series (1973-), *An Atlas of Airborne Pollen Grains and Common Spores of Canada* (1978), *Oats: Wild and Cultivated–A Monograph of The Genus* Avena L. (*Poaceae*) (1977), *Arctic Adaptations in Plants* (1972), *The Ferns and Fern Allies of Canada* (in press), *Mushrooms and Toadstools* (1927), *An Annotated Index of Plant Diseases in Canada* (1967), *Edible and Poisonous Mushrooms in Canada* (1962), *Compendium of Plant Disease and Decay Fungi in Canada* (in press), *Collection and Care of Botanical Specimens* (1962), *Fungi Canadenses* (1973-) a series dealing with descriptions and illustrations of fungi, *The Housefly,* Musa domestica *Linn. Its structure habits, development, relation to disease and control (*1914*), Canadian Bark-beetles. A preliminary classification, with an account of the habits and means of control* (1918), *Canada as an environment for insect life* (1956), *Canada and its insect fauna* (1979), *The mosquitoes of Canada (Diptera: Culicidae)* (1979), *Manual of nearctic Diptera Vol. 1* (1981) *Vol. 2* (in press), and *The fleas of Canada, Alaska and Greenland (Siphonaptera)* (1985).

In addition to these, many hundreds of taxonomic and other technical papers have been published in scientific journals and bulletins. Voucher specimens on which these papers have been based are deposited in the collections.

The research staff have also been involved in identifications of specimens for the public, environmentalists, other researchers, and police, and are frequently consulted on matters related to their fields of interest.

On 2 June 1986, a special ceremony was held on the lawn in front of the William Saunders Building at the Central Experimental Farm. This was to commemorate the centenary of the founding of the Experimental

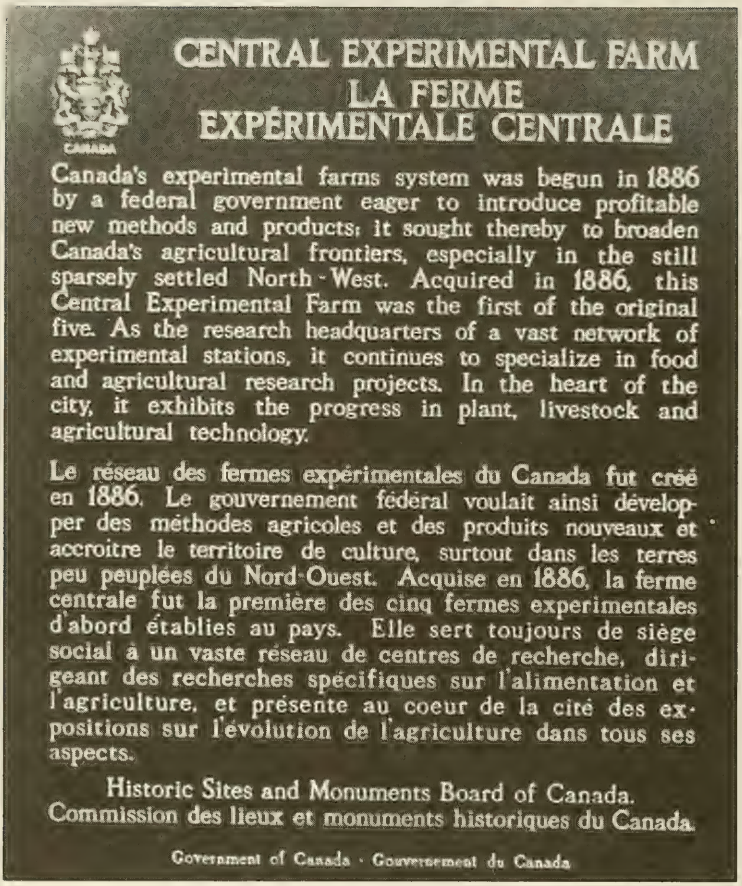

PLATE 3. National Historic Sites plaque.

Farms Service on 2 June 1886. Present were the Honorable John Wise, numerous dignitaries, invited guests and many members of staff and their friends. Included in this gathering were the President of The Ottawa Field-Naturalists' Club, W. K. Gummer, the Club's executive and seven of its past presidents. Mr. Gummer presented the portrait of James Fletcher (Plate 1) to Mr. Wise who in turn unveiled it. The portrait will be hung on the mezzanine of the William Saunders Building opposite the portrait of William Saunders. A plaque describing its history will be mounted on the wall beside it (see caption of Plate 1).

Another part of the ceremonies on 2 June was the unveiling of a National Historical Site plaque (Plate 3) by Mr. Wise. This plaque, like those for the other four experimental farms, will be mounted on a cairn where it can be viewed by visitors to the farm.

This is a year of special activities at many of the Agriculture Canada Research Branch establishments across the country. Such activities will include displays, lectures, special days and tours. We wish the Branch all success in their Centennial activities, and in addition a productive next hundred years.

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Additions to the Documentation of the Publication History of *The Canadian Field-Naturalist* and its Predecessors

DANIEL F. BRUNTON

Southwick Drive, R. R. 3 Manotick, Ontario K0A 2N0

In 1880, with the Ottawa Field-Naturalists' Club (hereafter, OFNC) less than a year old, the Council decided that ". . . it is desireable that the papers read before the Club during the past Season . . . should be printed as Transactions of the Club for the year 1879-80" (Public Archives of Canada OFNC Collection, MG 28, I 31, Volume 1, Minute Books, entry of 23 March 1880: references to the OFNC collections at the National Archives of Canada will be simplified hereafter to PAC, [entry date]). With that, a long and distinguished record of scientific and educational natural history publication was initiated.

Some details of the publication history have been documented (Boivin and Cody 1954; Cook 1982, 1986). Previously, however, only approximations could be made in establishing publication dates for the *Transactions of the Ottawa Field-Naturalists' Club* [1880-1887], as the editors of the *Transactions* were not given, and only formally listed editors of the *Ottawa Naturalist* were recognized. As a precise record of publication dates is potentially critical in establishing nomenclatural priority and it is of historical interest to know exactly who did the editing and when over the 102 volumes of Club publications, the following additional information from previously unsearched sources is given.

During the course of a long-term study of the OFNC, I have examined a number of the original Minute Books of the Club which are housed in the National Archives of Canada. These hand-written books contain a meticulous record of early Club Council meetings and the business meetings of the general membership, commencing with the inaugural meeting of the Club founders. Interestingly this is recorded as 25 March 1879 (PAC, 25 March 1879) not the originally published date of 19 March 1879 (Whyte 1880) subsequently accepted as the official beginning of the Club (Foxall 1979; Brodo 1981). The Minute Books include records of all formal motions of the Council and often relate the discussion that led up to them. Thus it was frequently possible to make close estimates of publication dates and to determine additional details concerning acting editors that were not recorded in the journal itself.

Publication dates

As Boivin and Cody (1954) supposed, the *Transactions* were not initially intended to form a periodical. Rather, each was to be an independent volume documenting the contents of lectures presented to the OFNC during the previous Club year (running April to the following March). The serialization of the *Transactions* only began when it became apparent after a number of years that the publication would be produced regularly and that it would be desirable to extend its scope. The OFNC publication was modelled on the *Transactions of the Manchester Field-Naturalists' Club* in England (PAC, 21 April 1880), probably on the suggestion of Club President James Fletcher who had recently (1874) emigrated from England. Fletcher was the driving force behind the establishment of the OFNC (Reddoch 1976; Gibson 1909).

Transactions No. 1 (1879-1880) was published between mid-May (when the final number of copies was approved by Council) and late July (when the final printing bill was accepted). A likely publication date, therefore, is ca. 15 June 1880. Five hundred copies were printed (PAC, 28 July 1880) and this became the standard number for all subsequent numbers of the *Transactions*.

Transactions No. 2 (1880-1881) was expected upon approval of the final publishing budget, in late July 1881 (PAC, 26 July 1881). Publication likely occurred within two weeks, judging from the timing of subsequent numbers (see below) and would likely have been ca. 5 August 1881.

Transactions No. 3 (1881-1882) had been published but was not yet distributed when copies were shown to the Council in late September 1882 (PAC, 27 September 1882). It was likely published that day or the day before.

Transactions No. 4 (1882-1883) was very late in being printed. It was released about 1 February 1884, as indicated by the Council being notified in late January that it would be out ". . . in a day or two . . ." (PAC, 28 January 1884). This delay is not explained but may be related to a preoccupation of Club officers with incorporation and fund-raising activities (Harrington 1884).

Transactions No. 5 (1883-1884) was ready to be published in late May 1884 but was held up by the financial difficulties being experienced by the printing

firm (PAC, 28 May 1884). These were brief, it would seem, since Recording-secretary Anderson reported being ". . . viciously attacked . . ." by a former printer who wanted a bigger share of OFNC business (PAC, 3 June 1884). This 'attack' presumably occurred after the printer had seen his rival's work — likely published about 1 June. (Not surprisingly, the Council decided to do no further business with the firm of the irate printer!)

Transactions No. 6 (1884-1885) was ready to be released in early March 1885 but was held up by a serious difficulty with the plates that were to accompany it (PAC, 9 March 1885). This became a major complication and with the absence of editors for extended periods during the year, delayed the number by almost a year. MacLaughlin (1887) noted that ". . . the issue . . . has . . . only just been made . . ." on 16 March 1886. As the Council had decided a week earlier to publish number six without the plates (which could be added later) (PAC, 9 March 1886), a likely publication date would appear to be ca. 13 March 1886.

Transactions No. 7 (1885-1886) was the final annual compilation of lecture material to be published and it was near completion in November 1886 (PAC, 16 November 1886). Like Number 6, however, difficulties arose and it was only released ". . . at the very close of the year . . ." (Harrington 1887). As the Club year closed on 20 March 1887, the likely publication date was about 10 March 1887.

The annual publication was done away with in favour of a monthly format because of the lengthy delay in the presentation of material. This was a particularly critical matter where a new species description was involved (Anonymous 1887).

In Boivin and Cody (1954), publication dates for *The Ottawa Naturalist* are estimated on the basis of the dates the issues were received at the National Museum of Natural Sciences and/or the printer's date noted on page one of many numbers. These vary quite widely from the intended first-of-the-month publication date and that variance is documented in Boivin and Cody's list. My review of OFNC Minute Books adds little to their estimates. It would appear that by the late 1880s the Publishing Committee functioned quite independently and only reported budgetary and major policy issues to the Council.

Editors

Cook (1982) did not have information on the editors of the *Transactions*; however, there is a detailed record of these in the Minute Books. The *Transactions* were edited by a committee of three individuals who were appointed by the Council at the start of each year. Called the Printing (and later, Publishing) Committee, they were responsible for all aspects of producing the *Transactions*. Table 1 lists the individuals who edited the volumes of the *Transactions* as determined from Council notes.

Only when the Council decided to publish the *Ottawa Naturalist* on a monthly basis was a single editor identified (PAC, 16 March 1887). The editorial record of the *Ottawa Naturalist* is more complex than recorded by Cook (1982) who used the listing on the inside front cover of each issue. Examination of the Minute Books shows that acting editors were appointed on a number of occasions and in one case an acting editor was responsible for an entire volume. Table 2 provides a revised list of editors based on the Minute Books. Several people who were not previously credited with editorial activities are now included (F. T. Shutt, W. T. Macoun, and J. A. Guignard).

This revision also modifies the length of service of a number of editors. Table 3 lists all editors of the *Transactions*, the *Ottawa Naturalist*, and the *Canadian Field-Naturalist* together with the period(s) each served. The 28 editors are listed in descending

TABLE 1. Editors of the *Transactions of the Ottawa Field-Naturalists' Club* and Dates of Publication.

Transaction Number	Editors	Estimated Publication Date
1 (1879-80)	J. Fletcher, R. B. Whyte, W. H. Harrington	15 June 1880
2 (1880-81)	W. L. Anderson, W. D. LeSeur, W. H. Harrington	5 August 1881
3 (1881-82)	R. B. Whyte, W. L. Scott, W. H. Harrington	27 September 1882
4 (1882-83)	W. L. Anderson, J. Fletcher, W. H. Harrington	1 February 1884
5 (1883-84)	W. L. Anderson, J. Fletcher, W. H. Harrington	1 June 1884
6 (1884-85)	J. Fletcher, W. L. Scott, F. D. Adams	13 March 1886
7 (1885-86)	W. H. Harrington, S. Woods, F. R. Latchford	10 March 1887

TABLE 2. Editors of the *Ottawa Naturalist*.
(Names appearing in italics are those of acting editors; the period served is noted in parentheses.)

Volume Number(s)	Years	Editors	Length of Service (volumes)
1	1887-88	W. H. Harrington (12 nos.)	1.0
2	1888-89	W. H. Harrington (April 1888 — 1 no.)	0.1
		J. Fletcher (May 1888-March 1889 — 9 nos.)	0.9
3-6	1889-93	J. Fletcher (38 nos.)	4.0
7-8	1893-95	W. H. Harrington (21 nos.)	2.0
9	1895-96	H. Ami (April 1895; Sept. 1895-March 1896 — 8 nos.	0.8
		A. G. Kingston (May-Aug 1895 — 4 nos.)	0.3
10	1896-97	H. Ami (12 nos.)	1.0
11	1897-98	H. Ami (April & May 1897; August 1897-March 1898 — 10 nos.)	0.8
		F. T. Shutt (June & July 1897 — 2 nos.)	0.2
12	1898-99	H. Ami (April-July 1898; November 1898-March 1899 — 9 nos.)	0.8
		W. T. Macoun (August & September 1898 — 2 nos.)	0.2
		F. T. Shutt (August & October 1898 — 2 nos.)	0.2
		J. Fletcher (October 1898 — 1 no.)	0.1
13	1899-1900	J. M. Macoun (April-October 1899 — 7 nos.)	0.6
		W. H. Harrington (November 1899-March 1900 — 5 nos.)	0.4
14	1900-01	J. M. Macoun (did not serve)	0.0
		J. Fletcher (all 11 issues)	1.0
15-16	1901-03	J. M. Macoun (24 issues)	2.0
17	1903-04	J. M. Macoun (December 1903-March 1904 — 4 nos.)	0.4
		J. A. Guignard (April-November 1903 — 8 nos.)	0.7
18-21	1904-07	J. M. Macoun (48 issues)	4.0
22	1907-08	J. M. Macoun (April 1907 — 1 no.)	0.1
		A. Gibson (May 1907-March 1908 — 11 nos.)	0.9
		W. H. Harrington (January 1909 — 1 no.)	0.1
		F. T. Shutt (January 1909 — 1 no.)	0.1
22-32	1909-19	A. Gibson (104 nos.)	10.0

order of length of service.

Fletcher, Shutt, W. T. Macoun, Guignard, Gibson, Senn, Hamilton and Mosquin were all from the Central Experimental Farm of the federal Department of Agriculture and had a combined 36 years of editorship. Ami was from the Geological Survey of Canada when the museum (later to be the National Museum Natural Sciences) was an integral part of it, and James M. Macoun, Jenness, Leachman, and Cook were also with the National Museum under one of its names — combining for a total of 32 years. This extraordinary contribution by the research (and in the case of Hamilton, editorial) staffs of "The Farm" and "The Museum" covers 68 years of the 107 years of OFNC publication. As Cook (1982) points out, Lorraine Smith, now only sixth in terms of years of editing, has the largest number of edited pages, averaging 125 pages over 36 issues (4509 pages).

James M. and William T. Macoun were the only members of the same family to serve as editor, and were sons of the famous field-naturalist John Macoun (Macoun 1979). William T. Macoun also served as Club President as did other editors: Whyte, Fletcher, Harrington, Ami, Gibson, Miller, Lewis, Mosquin, Leechman and Shutt.

Acknowledgment

Francis Cook suggested some restructuring of, and additions to, the original manuscript for which I must thank him.

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Anonymous. 1887. Editorial Announcement. Ottawa Naturalist 1: 9–10.

Boivin, B., and **W. J. Cody.** 1954. The Canadian Field-Naturalist and its Predecessors. Canadian Field-Naturalist 68: 127–132.

Brodo, I. M. 1981. The Ottawa Field-Naturalists' Club Centennial Symposium: 100 years of natural history in Canada. Canadian Field-Naturalist 95(1): 1.

Brunton, D. F. (*In press*). List of Original Descriptions Published in *The Canadian Field-Naturalist* (1932-1986). Canadian Field-Naturalist.

Cook, F. R. 1982. Editor's Report for 1981. Canadian Field-Naturalist 96: 220–223.

Cook, F. R. 1986. The "one hundredth volume" of *The Canadian Field-Naturalist*. Canadian Field-Naturalist 100(1): 140–143.

TABLE 3. Length of Service of Editors of the *Canadian Field-Naturalist* and its Predecessors.

Editor	No. of Volumes	Date of Term(s)
H. A. Senn	13.3	1941-1955
A. Gibson	12.9	1908-1920
D. Leechman	10.6	1928-1938
F. R. Cook*	10.3*	1962-1966; 1981- ?
J. Fletcher	10.0	1879-1880; 1883-1886; 1888-1893, 1898; 1900-1901
L. C. Smith	9.0	1972-1981
W. H. Harrington	8.6	1879-1885; 1887-1889; 1893-1895; 1899-1900; 1909
J. M. Macoun	7.0	1899-1909
R. A. Hamilton	6.0	1956-1961
T. Mosquin	5.8	1967-1972
H. Ami	3.3	1895-1899
H. F. Lewis	3.3	1922-1925
W. P. Anderson	3.0	1881-1882; 1883-1885
G. A. Miller	2.6	1925-1927
C. H. D. Clarke	2.0	1939-1940
W. L. Scott	2.0	1882-1883; 1885-1886
R. B. Whyte	2.0	1880-1881; 1882-1883
A. W. A. Brown	1.8	1940-1941

Individuals editing one volume or less: W. D. LeSeur (1881-1882), D. Jenness (1921), F. J. Nicolas (1928), F. D. Adams (1885-1886), A. G. Kingston (1895), F. T. Shutt (1897, 1898 and 1909), W. T. Macoun (1898), J. A. Guignard (1903), S. Woods (1885-1886) and F. R. Latchford (1885-1886).

*Incumbent editor (total to end of 1986). Note: Cook (1982) erroneously gave the years of his first editorial term as 1961-1966; correct years are as given here (FRC; personal communication).

Foxall R. 1979. One hundred years in perspective — the changing roles and objectives of the Ottawa Field-Naturalists' Club. Canadian Field-Naturalist 93(1): 1–5.

Gibson, A. 1909. James Fletcher, LL.D. Ottawa Naturalist 22: 189–191.

Harrington, W. H. 1884. Annual Report of the Council. Ottawa Field-Naturalists' Club Transactions 5: 5–6.

Harrington, W. H. 1887. Annual Report of the Council. Ottawa Naturalist 1: 11–16.

LaRocque, A. 1931. List of Original Descriptions Published by the Ottawa Field-Naturalists' Club. Canadian Field-Naturalist 45: 214–222.

MacLaughlin, T. J. 1887. Annual Report of the Council. Ottawa Field-Naturalists' Club Transactions 7: 289–291.

Macoun, John. 1979. Autobiography of John Macoun, M.A. (Second Edition). Special Publication No. 1, Ottawa Field-Naturalists' Club, Ottawa. 361 pp.

Reddoch, J. M. 1976. James Fletcher, "Father of the OFNC". Trail & Landscape 10: 110–115.

Whyte, R. B. 1880. Annual Report. Ottawa Field-Naturalists' Club. Transactions (1): 7–11.

Minutes of the 107th Annual Business Meeting of the Ottawa Field-Naturalists' Club: 14 January 1986

Place and Time: Auditorium, Victoria Memorial Museum Building, Metcalfe and McLeod Streets, Ottawa. 20:10 hrs.
Chairman: Mr. F. Pope, President
Attendance: About 55 people attended the meeting.

1. Minutes of the Previous Meeting

B. Martin, Recording Secretary, read the minutes of the 106th Annual Business Meeting.* It was moved by P. Ward (2nd J. Sankey) that the minutes be approved with the following amendments:

2(e) '. . consensus . . .'
5 '*J.* Harrison'
7(b) '. . . Society of *Ontario* Nut Growers . . .'

(*Motion Carried*)

It was noted that E. Bottomley was nominated to the Council in June, 1985.

2. Business Arising from the Minutes

F. Pope informed the meeting that the Council did indeed create a new By-law, allowing the Club to be called by the alternate style name of Ottawa Field Naturalists.

3. Finance

The Treasurer, P. Ward, presented the financial statements. He pointed out that this year the Anne Hanes Memorial Fund appears as a separate memorial fund, and that the Father Banim Fund has been merged with the Baldwin Fund.

The Ottawa Field-Naturalists' Club
Balance Sheet as of September 30, 1985

Assets

CURRENT	1985	1984
Cash and Term Deposits	$106 120	$77 277
Accounts Receivable	15 228	20 658
Accrued Interest	350	2 562
Prepaid Expenses	1 105	1 305
	$122 803	$101 802
FIXED		
Equipment		
Less: Accumulated Depreciation	918	1 468
Land: Alfred Bog	3 152	3 152
	4 070	4 620
	$126 873	$106 422

Liabilities Funds, and Members' Equity

	1985	1984
CURRENT LIABILITIES		
Accounts Payable	$15 917	$23 599
Deferred Income	10 487	10 763
	26 404	34 362
MEMORIAL FUNDS		
Anne Hanes	780	730
Baldwin	213	213
	993	943
OTHER FUNDS		
Carp Hills	12 675	200
Alfred Bog Protection	6 946	3 135
Seedathon	846	1 269
Bird Atlas Grant	500	Nil
	20 967	4 604
MEMBERS EQUITY		
Balance October 1, 1984	66 513	56 426
Income over Expenditure for Year		
The Ottawa Field Naturalists' Club	3 505	4 156
The Canadian Field-Naturalist	7 108	5 458
Centennial Projects	1 383	473
	78 509	66 513
TOTAL LIABILITIES FUNDS AND MEMBERS EQUITY	$126 873	$106 422

Statement of Income and Expenditure
The Ottawa Field-Naturalists' Club
for the year ended September 30, 1985

Income	1985	1984
Apportionment of Membership Fees		
Annual	$12 451	$11 764
Trail & Landscape		
Subscriptions	391	421
Back Numbers	447	36
Other Revenue	Nil	450
	838	907

*See *The Canadian Field-Naturalist* 99(3): 394–403.

Shrike Subscriptions	907	658
Donations	2 000	2 943
	16 196	16 272
Interest	1 806	1 297
Total	18 002	17 569
Expenditure		
Trail & Landscape		
Publishing	5 744	5 130
Circulation	301	305
Editing and Office	348	165
Honoraria	550	550
	6 943	6 150
Shrike Publishing	706	685
Committee Activities — Net		
Excursions and Lectures	(426)	(276)
Membership	1 055	1 059
Macoun Field Club	335	301
Conservation	110	188
Birds	1 075	108
Publications	Nil	53
Affiliation Fees	326	281
Baldwin Scholarship	150	150
Office Assistant	439	416
Office Supplies and Expenses	1 950	1 982
Computer Charges	1 114	1 841
Miscellaneous	720	475
	6 848	6 578
Total	14 497	13 413
Excess of Income over Expenditure	$ 3 505	$ 4 156

Statement of Income and Expenditure
The Canadian Field-Naturalist
for the year ended September 30, 1985

Income	1985	1984
Apportionment of Membership Fees		
Annual	$ 8 300	$ 8 043
Subscriptions	21 694	20 591
	29 994	28 634
Publication		
Reprints	8 867	12 816
Plates and Tab Settings	3 360	2 045
Extra Pages	22 903	16 890
Back Numbers	751	2 341
	35 881	34 092
Other		
Interest	7 424	4 989
Exchange	2 124	1 715
	9 548	6 704
TOTAL	75 423	69 430

Expenditure		
Publishing	48 201	42 997
Reprints	6 906	7 250
Circulation	5 680	8 562
Editing	2 000	140
Office Assistant	2 862	2 713
Office Supplies	786	289
Honoraria	1 880	2 021
	68 315	63 972
Excess of Income over Expenditure	$ 7 108	$ 5 458

Notes to the Financial Statements
September 30, 1985

1. *Authority and Activities*
THE OTTAWA FIELD-NATURALISTS' CLUB is a non-profit organization incorporated under the laws of the Province of Ontario (1884). The Ottawa Field-Naturalists' Club promotes the appreciation, preservation and conservation of Canada's natural heritage; encourages investigation and publishes the results of research in all fields of natural history and diffuses information on these fields as widely as possible. It also supports and co-operates with organizations engaged in preserving, maintaining or restoring environments of high quality for living things. Membership is open to any person or family, upon application and payment of dues. Payment of the Annual Dues as set out in the By-laws will be a necessary condition for the continuance of Membership.

2. *Significant Accounting Policies*
Memberships, subscriptions and donations are recorded as received. All other revenues and expenditures are recorded on the accrual basis.

Auditor's Report
To: Members of The Ottawa Field-Naturalists' Club

I have examined the balance sheet of The Ottawa Field-Naturalists' Club as of September 30, 1985, and the related Income Statements for the year then ended. My examination included a general review of the accounting procedures and such tests of the records and supporting vouchers as considered necessary under the circumstances.

In my opinion, these financial statements present fairly the financial position of the organization as of September 30, 1985, and the results of its operations for the year then ended in accordance with generally accepted accounting principles.

F. MONTGOMERY BRIGHAM

January 8, 1986

The following comments were made:

a) The computer printer appears as a fixed asset.
b) It was affirmed that the Anne Hanes Fund had accrued interest.
c) The Birds Committee expenditure of $1075 included the new Bird Hot Line and some bird feed.
d) There will be no fee increase this year.

P. Ward moved (2nd L. Maltby) to accept the financial statement.

(*Motion Carried*)

P. Ward thanked M. Brigham for doing the auditing this year.

F. Pope thanked P. Ward for presenting such concise financial statements.

4. Report of Council

This report consists of reports by Committees of the Council.

Awards Committee

Bill Gummer (Chairman)	Ken Taylor
Peter Hall	Harry Thomson
Mary Stuart	Sheila Thomson

A total of 32 nominations was received (25 different names submitted by eight people) for the 1984 Club awards. Not all nominations came from Council members. The Awards Committee would like to see even more participation from the general membership. As well as nominations for O.F.N.C. awards, several people were nominated for 'outside' awards. Council accepted the recommendations of the Awards Committee and the successful candidates are listed below:

O.F.N.C. Awards:

— Honorary Membership:	C. Stuart Houston
	Eugene G. Munroe
— Member of the Year:	Frank H. Bell
— Service:	Daniel F. Brunton
— Conservation:	Roger Taylor

Other Awards:
— Pollution Probe Environmental Awareness Award: Marey Gregory
— Federation of Ontario Naturalists Achievement Certificate: Jocelyn Webber

The remaining O.F.N.C. Award, the Anne Hanes Natural History Award, was not awarded for 1984 as there was no suitable candidate. Certificates were presented at the 1985 Soirée. Citations appeared in *Trail & Landscape* 19(4):196 and will appear in *The Canadian Field-Naturalist*.*

During the year one of the Club's recently awarded Honorary Members, Dr. Bernard Boivin, passed away, leaving the total number of Honorary Members at 20.

The Committee has discussed the addition of another Club award of a more general nature — to recognize members who do a great deal for the Club but do not fit into any of the existing award categories. No decision has yet been taken on this.

A few nominations have been received for consideration for 1985 awards.

(*W. K. Gummer*)

**The Canadian Field-Naturalist* 99(4): 547–548.

Birds Committee

V. Bernard Ladouceur (Chairman)	Bill Gummer
C. Wright Smith (Secretary)	Jeff Harrison
Frank Bell	Christine Hanrahan
Robert Bracken	Roy John
Mark Gawn	Gordon Pringle
Stephen Gawn	Art Thompson
	Daniel Toussaint

SUBCOMMITTEES:

Bird Records

Roy John (Chairman)	Robert Gorman
Gordon Pringle (Secretary)	V. Bernard Ladouceur
Robert Bracken	Stephen O'Donnell
F. Montgomery Brigham	Michael Runtz
Mark Gawn	

Ontario Breeding Bird Atlas

Christine Hanrahan (Chairman)	Mark Gawn
Frank Bell	Roy John
	Paul Jones

Bird Feeders

Gordon Pringle (Chairman)

Feeder Operators:

— Jack Pine Trail	— Roy Millen
— Rockcliffe Park	— Stephen Darbyshire
— Pink Road	— Club des Ornithologues de l'Outaouais
— Davidson Road	— George McGee
— Hazeldean Woods	— David Easton
— Mer Bleue	— John Sankey Daniel Perrier

1985 was a typical year for the Birds Committee with the usual mix of accomplishments and controversy. The major accomplishment was the successful completion of the Ontario Breeding Bird Atlas for the Ottawa region. All 76 of the Ottawa 'squares' (10 km × 10 km) received adequate coverage. In addition to this, 35 squares given to the Ottawa region from other regions were successfully completed. The special problems of 'atlassing' nocturnal birds and atlassing seven squares in the Algonquin Park region were tackled by Mark Gawn and Paul Jones, respectively, yielding outstanding results.

Special praise must go to Christine Hanrahan, Chairman of the Ontario Breeding Bird Atlas Subcommittee, who has done the bulk of the work for the last two years. The volume of this day-in and day-out drudgery has been incredible.

The Bird Records Subcommittee had a productive year under the chairmanship of Roy John. A new Birder's Checklist of Ottawa was produced. The Committee would like to thank Barbara LeBeau for her fine graphics work. The Bird Records Subcommittee also kept up-to-date with the rare bird reports submitted.

Gordon Pringle was again in charge of bird feeders. This year, two new feeders were added bringing the number of O.F.N.C. birdfeeding stations to six. The new locations are Mer Bleue (formerly run by the National Capital Commission) and Hazeldean Woods.

On September 8th Bruce Di Labio, Richard Brouillet and Bernard Ladouceur participated in the fifth annual Bird Seed-

a-thon. Bruce Di Labio deserves most of the credit for the more than $600 raised.

Feeders are just one way in which The Ottawa Field-Naturalists' Club serves the birding general public. In 1985 a Bird Hot-line (744-4704) was implemented. John Sankey was instrumental in bringing this dormant idea to fruition.

The Ottawa Christmas Bird Count was held on December 22nd with a new main compiler, Allan Cameron, who did a fine job. Bernard Ladouceur stepped down as compiler after seven years of service. A substantial minority of the participants did not pay the $4.25 Audubon fee. This is a contentious issue which will probably come to a head in 1986. The O.F.N.C. Council may be asked to decide whether or not it wants the Ottawa Christmas Bird Count to continue to be sponsored by the National Audubon Society.

Finally, the Birds Committee has decided to hold fewer meetings in 1986. The usual ten meetings will be reduced to six or seven. Aside from regular business, each meeting will have a specific topic to be covered.

Proposed meetings for 1986:
— Jan. 30: General Agenda for 1986
— Mar. 27: Quebec Breeding Bird Atlas
— Apr. 24: Spring Bird Count
— Jul. 31: Fall Bird Count & Seed-a-thon
— Sep. 25: Bird Feeders
— Oct. 30 (if necessary): Christmas Bird Count
— Dec. 11: Christmas Bird Count

Hopefully, this approach will increase interest in the activities of the Birds Committee in 1986.

(*V. B. Ladouceur*)

Conservation Committee

Lynda Maltby (Chairman)	Philip Martin
Carolyn Harris (Secretary)	Joyce Reddoch
Bill Arthurs	Gregg Sheehy
Eleanor Bottomley	Roger Taylor
Stew Hamill	Ewen Todd
Barbara Martin	Scott Wilson

In 1985, the Conservation Committee continued its involvement in local, provincial and national issues.

Local Issues

The Carp Hills subdivision proposal continued to be a main item for the Committee. The Ontario Divisional Court hearing was held July 3rd in Toronto. Following an all-day session, the Court ruled that Ottawa-Carelton Regional Council was deemed to have made a decision prior to the request of The Ottawa Field-Naturalists' Club for a referral to the Ontario Municipal Board. The developer (Aselford-Bradley) has submitted drainage plans for the development plan.

Committee members have continued to represent the O.F.N.C. on the Marlborough Forest Advisory Committee. The Ontario Ministry of Natural Resources, Carleton Place, was also interested in O.F.N.C. input regarding sensitive areas in the forest. At least two field trips were scheduled, one in the winter and one in the spring.

A third alternative for storm drainage in the Britannia Woods-Mud Lake area was presented by Proctor and Redfern Engineering. Members of the Conservation Committee reviewed and made comments on the consultant's report. Basically, the O.F.N.C. was pleased that there would be no increase in the flow of stormwater to Mud Lake but was disappointed with the environmental appraisal of the area.

The Committee has been actively involved in the 25-year management plan being developed for the region by the Regional Municipality of Ottawa-Carleton Waste Management Task Force. The WastePlan group has been having public meetings over the past few months. Reduction and recycling will be incorporated in the plan although the details have not yet been decided upon. Consideration is also being given to composting and incineration and incineration as energy from waste. Twelve candidate land fill sites are being considered throughout the region. A WastePlan fact sheet is available to anyone who requests it but the criteria used for selection of sites are not well defined. Several members attended public meetings. The sites are to be narrowed down to three by the first of the new year (1986) and the Committee will be involved in assuring that the technical aspects of each site should be examined and evaluated.

Provincial Issues

The Committee made a submission to Wildlife Habitat Canada for the preservation of Alfred Bog. Funding was deferred but the proposal was supported in principle. A display was also included at the Canadian Nature Federation Annual Meeting held on July 6th at Carleton University so that more support could be mustered from those people interested in preserving this unique area. The O.F.N.C., jointly with the Nature Conservancy of Canada, sponsored a meeting of interested parties on October 23rd. Representatives from the following organizations [which include the two sponsors] were contacted: Canadian National Sportsmens Fund, Canadian Nature Federation, Canadian Wildlife Federation, Canadian Wildlife Service, Catharine Traill Naturalists' Club, Ducks Unlimited, Federation of Ontario Naturalists, Nature Conservancy of Canada, Ontario Heritage Foundation, Ontario Ministry of Natural Resources, Ottawa Duck Club, The Ottawa Field-Naturalists' Club, South Nation Conservation authority, Vankleek Hill Naturalists, Wildlife Habitat Canada, Wildlife Society of Canada, and World Wildlife Fund. It was decided to establish a Steering Committee to pursue the protection of the Bog. The Steering Committee consists of representatives from the South Nation Conservation Authority, the Ontario Ministry of Natural Resources, the local naturalist community and a funding agency.

As described in *Trail & Landscape* 19(4):189, Aleta Karstad offered to the Club a painting of Alfred Bog for the purpose of raising money for the Alfred Bog Fund. The raffle is being co-ordinated by the Conservation Committee and will be held at the 1986 Soirée.

Other provincial issues undertaken by the Committee included meetings associated with the future of lake trout in Ontario, a vegetation study of Constance Bay, the corridor for the Eastern Ontario transmission lines, Ontario Waste Management, O.M.N.R. aerial spraying in northern Ontario, Glen Elbe Drain, Provincial Parks Policy, Working Paper No. 40, Ontario Environmental Network and other items.

National Issues

Support was given, in principle, for the conservation efforts of the Canadian Nature Federation for the preservation of Canada's Galapagos, South Moresby.

A presentation was given by D. Neave of Wildlife Habitat Canada outlining the objectives of his organization.

The 100th Anniversary of Wildlife Conservation: The first migratory bird sanctuary in North America was established at Last Mountain Lake, Saskatchewan in 1887. The Canadian Nature Federation has prepared a proposal to have public celebrations that would 'rekindle and focus public attention' on wildlife conservation in Canada. The Conservation Committee supports the proposal in principle.

The Chairman, Lynda Maltby, would like to thank all Conservation members for their active involvement this past year. Special mention must be given to Carolyn Harris for her dedicated effort as Secretary and to Eleanor Bottomley as Co-Chairman of the Conservation Committee.

(*L. S. Maltby*)

Education and Publicity Committee

Betty Marwood (Chairman)	Patricia Narraway
Bill Arthurs	M. Peacock
Jack Gillett	G. Rath
Bill Knight	P. Ronan
D. Métras	Ken Taylor
C. Montgomery	B. Teager

The Education and Publicity Committee had a variety of activities in 1985: leaders were recruited for a cub pack excursion and for walks at the Billings Estate and a photo essay program was presented at the Beacon Hill Lodge nursing home.

A write-up was prepared to accompany the set of 50 bird slides which had been purchased from Cornell University through the efforts of George McGee. An ad was placed in *Trail & Landscape* for people to help George McGee with his bird education project, but there were few responses.

The Committee contributed to a list prepared by Barbara Martin of what the O.F.N.C. does for the public.

Again in 1985 the Committee co-ordinated the judging and presentation of The Ottawa Field-Naturalists' Club special awards at the Ottawa Regional Science Fair. This year's winners were Phillip Isotalo for his project on Lepidoptera, Sabrina Magro and Debbie Rofner for their exhibit on Creation of Hybrids by Cross-Pollination, and Vijay Chauhan for his Chemical Model to Predict *In-Vivo* Metabolism of Xenobiotics. Each exhibit was awarded a cash prize of $40 and a one-year membershp to The Ottawa Field-Naturalists' Club.

Ken Taylor would like to thank the members of the Education and Publicity Committee and all the others who helped with the various activities.

(*K. Taylor for B. Marwood*)

Excursions and Lectures Committee

Philip Martin (Chairman)	Bill Gummer
Frank Bell	Peter Hall
Allan Cameron	Jeff Harrison
Ellaine Dickson	Richard Leavens
Eileen Evans	Robert Taylor
C. Gaskell	

Fifty-four excursions were organized by the Committee during the year. These comprised fifteen of general interest and twenty-four with particular reference to birds, seven to botany, one for amphibians, one for mushrooms, one for geology, two for butterflies and one each for insects and for butterflies and plants of the Ottawa area. The trip to St. Lawrence Islands National Park and the trip to The Haven at Lac La Pêche were arranged in conjunction with Parks Canada and the National Capital Commission, respectively. The schedule on both trips was fairly intensive and required a good deal of planning on the part of the staff of these organizations. All the excursions were well attended and seem to have been appreciated.

Nine monthly meetings in addition to the Annual Business Meeting were held in the Auditorium of the National Museum of Natural Sciences on McLeod St. Titles of the evening presentations included *Spring Wildflowers, What makes the Conservation Committee Tick, An Artist in the Arctic, Alladin's Garden* (on the birds and flora of Trinidad and Tobago), *Reptiles and Amphibians of the Ottawa Area, Members' Slide Night, Breakfast with the Vancouver Island Marmot, Don't Bring it Back* (on the rationale of plant quarantine), and *The Gypsy Moth — Unwelcome Vagabond.*

On 22 November, the Committee collaborated with the Membership Committee to arrange a wine and cheese party for new members to the Club (see Report of the Membership Committee).

The Annual Soirée, held at the First Unitarian Church on 19 April, took the form of a pot luck supper to which all participants contributed a dish — a change in the customary event which was enthusiastically received. The Ottawa Bird Banding Group raffled a print of a lynx by Glen Loates. An account of the Soirée can be found in *Trail & Landscape* 19(4): 194–195.

The Committee wishes to express its sincere thanks to speakers and leaders. We are also grateful to the Museum staff for helping with projection of slides and other duties and for the provision of the Dinobus for Club outings.

(*P. Martin*)

Finance Committee

William Arthurs (Chairman Jan.-Sep.)	William Cody
Daniel Brunton (Chairman Oct.-Dec.)	Fran Goodspeed
Ronald Bedford	Charles Gruchy
	C. Rounding
	Paul Ward

One formal meeting and several informal telephone conferences were held during the past year. The Ottawa Field-Naturalists' Club policy on the pricing of Club sales items and the issuing of receipts for income tax purposes for life memberships were reviewed. The Committee's conclusions were presented to the Council and, as a result, new Club policies were developed in these areas.

The finances of the Club remain sound. The anticipated need for a fee increase in 1986 has been avoided by good management and economy in various Club programs — most notably in our publications.

An agenda of issues to be considered was prepared at the end of 1985 to guide the 1986 Committee's discussions.

Bill Arthurs resigned as Chairman of the Finance Committee towards the end of 1985 after several years of service in that capacity. Dan Brunton was selected by the Council to complete Arthur's term as Chairman, pending selection of the new Committee for 1986.

(*D. F. Brunton*)

Macoun Field Club

Don Fillman (Chairman)

Marc Bosc	Bill Gummer
Fenja Brodo	Dorothy Laurin
Robin Collins	Robert Lee
Stephen Darbyshire	Julie Murphy
David Easton	Vic Solman

The Macoun Field Club had a successful program of speakers and field trips in 1985. The groups have the following numbers of regular attendees: less than 20 Juniors, about 15 Intermediates and a dozen Seniors. The Seniors, a particularly promising group, have begun a program of Museum workshops. They have completed a workshop in paleobiology and in 1986 hope to continue with zooarchaeology, botany and taxidermy. Robin Collins has continued to lead all three groups (Juniors, Intermediates, and Seniors) and has done so in an exemplary manner.

Field trips and excursions, now offered twice a month, have been the most popular part of the program. The field trips have concentrated on the Moodie Drive Study Area, but in 1986 the Committee hopes to diversify the field program to such locations as Mer Bleue and Luskville Caves. With as many as 50 children on field trips, the Committee has found supervision and expertise too thinly spread. The Macoun Field Club could still use help on its field trips, and is hoping to get help this coming year from the other Club Committees.

The Macoun Field Club has put out a monthly newsletter. *The Little Bear* has come along slowly and is going to be printed every two months. In May 1986 the 1984-85-86 edition will be put together under one cover.

The Committee would like to thank Martha Camfield, Connie Downes, Fenja Brodo and Rob Lee for their able assistance in running the Macoun Field Club program.

(*R. Collins and D. Fillman*)

Membership Committee

Barbara Campbell (Chairman)	Bill Gummer
Eleanor Bottomley	Luella Howden
Ellaine Dickson	Aileen Mason
Fran Goodspeed	Betty Stern
	Ken Strang

Club membership declined slightly in 1985. Local membership increased by 18 and non-local membership decreased by 40. The number of new members joining the Club was 172 compared to 168 new members in 1984. The total membership in the Club as of December 1985 was 1211, a decrease of 22 from the 1984 total of 1233. Family membership totalled 338 — an increase of 15 over last year. Based on an average of two members per family, we estimate the total membership served by the Club to be 1549.

The accompanying table shows a summary of membership distribution.

Thirty-seven new names were added to our Volunteer List. These lists, which are circulated to the various committees, provide a valuable source of help to run the Club. The Committee would like to thank all of those people who have offered their help.

This year, Membership Committee and Excursions and Lectures Committee co-hosted a New Members' Night on November 22nd. There was an excellent turn-out of about 80 people despite the weather. Wine and cheese were served in the salon of the National Museum of Natural Sciences. The event provided an excellent opportunity for new members to meet Council, some of the Club's Honorary members, and each other and to get a chance to learn how the Club works. Many thanks to all who participated in this successful event.

The Chairman, Barbara Campbell, would like to thank all the members of the Committee for their help in 1985, with a special thanks to Patricia Narraway for her ever-present help in overseeing the computer operations.

(*B. Campbell*)

Publications Committee

Ronald Bedford (Chairman)	Bill Gummer
Bill Arthurs	Jim Montgomery
Paul Catling	Joyce Reddoch
Bill Cody	John Sankey
Francis Cook	

The Publications Committee continued to act as an advisory body to Council on the Club's publications.

Four issues of *The Canadian Field-Naturalist* were published in 1985: Volume *98*, issue 4, and Volume *99*, issues 1–3. The last of these is the largest single issue of *The Canadian Field-Naturalist* ever published. The publication schedule slipped somewhat, but at year's end the Committee is happy to report that the journal is in excellent shape for 1986. Statistically, these four issues comprise 598 pages, 59 articles,

1985 MEMBERSHIP IN THE OTTAWA FIELD-NATURALISTS' CLUB

	CANADA		FOREIGN		
Type	Local	Other	USA	Other	Total
Individual	450 (463)	266 (295)	59 (68)	5 (5)	780 (831)
Family	309 (291)	28 (31)	1 (1)	0 (0)	338 (323)
Sustaining	36 (24)	3 (3)	0 (0)	0 (0)	39 (27)
Life	12 (12)	18 (18)	3 (3)	1 (1)	34 (34)
Honorary	14 (13)	5 (4)	1 (1)	0 (0)	20 (18)
Total	821 (803)	320 (351)	64 (73)	6 (6)	1211 (1233)

Note: Figures in parentheses contain 1984 totals.

41 notes, 56 book reviews, 272 new titles, 1 commemorative tribute and the usual allotment of news and comments. Among the 59 articles were eight COSEWIC reports on the status of endangered Canadian species. The material for the next three issues is already in an advanced stage of preparation. The flow of manuscripts to the editorial office continues at a steady and manageable pace. There were no changes of Associate Editors in 1985.

Trail & Landscape continued its impeccable record with five issues — 272 pages of articles, reviews, comments and calendars of Club events. In summary, Volume *19* was 272 pages of 'can't put down until the last page is turned' reading on local natural history. Especially noteworthy was the three-part series by Daniel F. Brunton entitled 'Recent Significant Plant Records for the Ottawa District'. It is also a pleasure to acknowledge Ross Anderson's continuing, delightfully illustrated, offbeat series on various flora and fauna. Preparations for a cumulative index of Volumes 1 to 20 are well in hand.

The Shrike has struggled during 1985. Collection of data on local bird sightings has continued unabated, but there has been a dearth of willing and deadline-observing writers to prepare the ever-popular sightings' descriptions and analyses. As a result, publication has lagged behind schedule. Five issues appeared: Volume *9*, issues 5 and 6 and Volume *10*, issues 1–3, for a total of about 115 pages. In an effort to overcome the above difficulties, the expected six issues of Volume *10* will be compressed into five, with issue 3 carrying the May-July sighting reports, and issue 4, the August-October. efforts are being made to circumvent the difficulties and to get *The Shrike* back on schedule and on firm footing.

A year ago the Committee was considering a special publication, which unfortunately had to be abandoned when the hoped-for funding failed to materialize. Negotiations for the production of another special publication are in progress.

The Publications Committee acknowledges with thanks the efforts of all connected with the publication of these journals, which provide so many hours of enjoyment for Club members.

(*R. E. Bedford*)

The report was read by F. Pope and W. Gummer. After each committee report there was an opportunity for comments.

(a) *Awards Committee*

E. Dickson inquired whether or not the general membership had been informed that it can nominate people for Club awards. W. Gummer replied that the call for nominations is advertised in *Trail & Landscape*.

(b) *Birds Committee*

F. Pope commended the Committee on an outstanding year.

(c) *Education and Publicity Committee*

W. Gummer commented that Phillip Isotalo, one of the recipients of The Ottawa Field-Naturalists' Club special awards at the Ottawa Regional Science Fair, attended the New Members' Night and has become a very active Club member.

(d) *Excursions and Lectures Committee*

Once again, many thanks to Jean (Hastie) and Herb Valiant for looking after the refreshments throughout the year.

P. Ward moved (2nd L. Maltby) to accept the Report of Council.

(*Motion Carried*)

F. Pope commented that he felt very proud of the Club's accomplishments last year.

5. Nomination of Auditor

W. Cody moved (2nd E. Dickson) that F.M. Brigham be appointed to audit the accounts of The Ottawa Field-Naturalists' Club for the 1985-86 fiscal year.

(*Motion Carried*)

6. Nominations

B. Campbell, Chairman of the Nominations Committee, presented the following slate for the 1986 Council:

The Executive:

President	W. Gummer
Vice-President	B. Campbell
Vice-President	J. Harrison
Treasurer	P. Ward
Recording Secretary	E. Bottomley
Corresponding Secretary	B. Martin

Other Members of the Council:

*R. Anderson	D. Fillman
R. Bedford	*F. Levine
D. Brunton	L. Maltby
*A. Cameron	*R. Milko
W. Cody	F. Pope
F. Cook	*J. Reddoch
E. Dickson	R. Taylor
*E. Evans	*D. Thompson

*New Member of Council

B. Campbell moved (2nd P. Martin) that the slate of nominations be approved.

(*Motion Carried*)

The President welcomed the new members of Council. He then said a few words about each of the retiring members of Council and thanked them for their services. Retiring were:

W. Arthurs	P. Martin
A. Hackman	B. Marwood
B. Ladouceur	P. Narraway
A. Martell	K. Taylor

7. New Business

(a) F. Pope talked a bit about Aleta Karstad's painting of a scene in Alfred Bog, on display at the front of the stage. The painting is to be raffled off at the Soirée in May and the proceeds will go the Alfred Bog Fund.

(b) F. Pope told the meeting that Frank Bell had been quite ill recently and anyone wishing to sign the card to be sent to him from the Club could do so after the meeting. Because of his illness, Bell will be replaced by Peter Hall and Paul Catling for the February 11 monthly meeting.

(c) Ruth Durance told the meeting that she had six bluebird houses made out of scrap by Frank Safo. Since she had nowhere to put them, she offered them to anyone who wanted one.

(d) The outgoing President, F. Pope, said how much he had enjoyed his term of office, thanked the many people who had helped by their activity in Club affairs, and finally, wished the new President good luck.

(e) The incoming President, W. Gummer, then made a few remarks.

8. Adjournment

J. Sankey moved (2nd P. Ward) that the meeting be adjourned. Time: 21:20 hrs.

(*Motion Carried*)

9. Following the business meeting, the group met for coffee and dessert and then broke into four discussion groups to discuss various aspects of the Club's activities:

— Awards, Education & Publicity, Macoun
— Birds, Excursions & Lectures
— Conservaton
— Finance, Membership, Publications

B. J. MARTIN
Recording Secretary

The Constitution of The Ottawa Field-Naturalists' Club

(January 1986)

Articles of the Constitution

Article 1. Name and Status

This Club shall be known as The OTTAWA FIELD-NATURALISTS' CLUB. It is a non-profit organization incorporated under the laws of the Province of Ontario (1884).

All assets and other accretions of the Club shall be used in promoting the Objectives of the Club and in no way shall be used for the purpose of financial gain for its members. In the event of dissolution of the Club, all remaining assets, after payment of liabilities, shall be distributed to one or more recognized charitable organizations in Canada.

Article 2. Objectives

The objectives of this Club shall be to promote the appreciation, preservation and conservation of Canada's natural heritage; to encourage investigation and publish the results of research in all fields of natural history and to diffuse information on these fields as widely as possible; to support and co-operate with organizations engaged in preserving, maintaining or restoring environments of high quality for living things.

Article 3. Membership

Any persons or family shall, upon application and payment of dues, become a member of the Club. Payment of the Annual Dues as set out in the By-laws will be a necessary condition for the continuance of Membership.

(1) *Individual Membership*
A person shall be granted an Individual Membership upon payment of the annual fee, the amount of which shall be set out in the By-Laws.

(2) *Family Membership*
A family shall consist of husband and wife (or either) and any dependent children up to the age of eighteen. A family shall be granted a Family Membership upon payment of the annual fee, the amount of which shall be set out in the By-laws.

(3) *Sustaining Membership*
A person or family shall be granted a Sustaining Membership upon payment of an annual fee, the amount of which shall be set out in the By-laws.

(4) *Life Membership*
A person shall be granted a Life Membership upon a single payment of a fee, the amount of which shall be set out in the By-laws.

(5) *Honorary Membership*
Any person who has, to a marked degree, assisted toward the successful working of the Club, or who has made an outstanding contribution to Canadian natural history may be elected by the Council to Honorary Membership in the Club. The family of an Honorary Member shall be granted the privileges of Family Membership.

(6) *Privileges of Membership*
Members may participate in the activities of the Club. Each Membership shall receive one copy of each issue of the current volume of *The Canadian Field-Naturalist*, and a copy of the Constitution and By-laws. Members, excepting dependent children, may hold office and may vote at the Annual Business Meeting or at a Special Business Meeting.

Article 4. Institutions

Institutions cannot hold Membership in the Club

but may subscribe to the publications of the Club and make donations to the Club.

Article 5. Benefactors

Benefactors shall be those persons from whom the Club shall accept the sum of $500 or more. A list of Benefactors shall be published in *The Canadian Field-Naturalist*.

Article 6. Patrons

The Council shall have power to elect a Patron or Patrons, not to exceed two in number at any time, after his or their consent has been obtained.

Article 7. Club Funds

The Club shall maintain two permanent funds to be known as the Current Fund and the Reserve Fund.

(1) *Current Fund*
This fund shall contain the working moneys of the Club for current operations. It shall receive all normal income such as regular membership fees and any other moneys not specifically allocated to other purposes.

(2) *Reserve Fund*
This fund shall contain moneys invested so as to maximize long-term capital growth while maintaining sufficient flexibility to provide money on short notice for special requirements as needed.

Article 8. Officers

The officers of the Club shall be a President, a First Vice-President, a Second Vice-President, a Recording Secretary, a Corresponding Secretary, and a Treasurer.

Article 9. The Council

The Council shall consist of the officers of the Club and up to eighteen additional members. In addition, the retiring President shall continue as a member of the Council for the Club year following his retirement.

The Council shall meet from time to time at the call of the President or any two other of its members; it shall manage all matters affecting the welfare and activities of the Club; it shall have control of the funds of the Club; it shall present at the Annual Business Meeting a report of the year's work. This report shall be published in *The Canadian Field-Naturalist*.

Article 10. Standing Committees

Seven standing committees, each consisting of at least six members, shall be appointed by the Council, namely: An Executive Committee, a Publications Committee, an Excursions and Lectures Committee, a Finance Committee, a Conservation Committee, a Membership Committee, and an Awards Committee. The chairman of the Executive Committee shall be the President. The Chairman of each other standing committee shall be chosen from among the members of the Council.

Both Vice-Presidents and the Recording Secretary shall be members of the Executive Committee. The membership of each standing committee shall contain at least one of the Vice-Presidents. The Treasurer and the Business Manager of *The Canadian Field-Naturalist* shall be members of the Finance Committee. The Editor of *The Canadian Field-Naturalist* and the Business Manager of *The Canadian Field-Naturalist* shall be members of the Publications Committee. The Chairmen of the Excursions and Lectures Committee, the Conservation Committee, and the Membership Committee shall have power to add to their committees.

Article 11. Auditor

An Auditor shall be elected by open vote at the Annual Business Meeting. The Auditor shall examine the Treasurer's accounts and certify as to their correctness.

Article 12. Business Meetings

The Annual Business Meeting of the Club shall be held in January.

A Special Business Meeting of the Club shall be called by the Recording Secretary on the request of ten voting members. The Recording Secretary shall specify in the notice of meeting the nature of business to be transacted. At this meeting no business other than that for which the meeting was called shall be transacted except by unanimous decision of those present.

Article 13. Elections and Appointments

The officers of the Club and the additional members of the Council shall be elected annually. The nomination of sufficient persons for election to the various offices and membership of the Council shall be the responsibility of a Nominating Committee, which shall act in a manner prescribed in the By-laws.

The Council shall, at the earliest possible date, appoint chairmen and members of Standing and Special Committees, and Editors and Business Managers, as required, for club publications.

The Council shall have the power to accept any resignation and to appoint any member of the Club to fill any vacancy for the remainder of the original term of office.

Article 14. Term of Office

All members of the Council, auditors, and committee members elected or appointed pursuant to Articles 9, 11 and 13 shall commence their duties at the close of the meeting at which they are elected or appointed, and shall serve until the end of the next Annual Business Meeting or until their successors are appointed. Appointments of Editors and Business Managers of club publications pursuant to Article 13 shall be for specified terms not exceeding three years, and shall be renewable.

Article 15. Quorum

Twenty members shall constitute a Quorum at the Annual Business meeting or at any Special Business Meeting of the Club, and seven members shall constitute a Quorum of the Council.

Article 16. Duties of the President

The President shall arrange, and preside at, Business Meetings of the Club and at meetings of the Council. He shall be, ex-officio, a member of all Committees of the Club.

Article 17. Duties of the Vice-Presidents

In the absence of the President, or at his request, either the First or Second Vice-President shall act in his stead. Both Vice-Presidents shall be members of the Executive Committee. The membership of each standing committee shall contain at least one of the Vice-Presidents.

Article 18. Duties of the Recording Secretary

The Recording Secretary shall keep minutes of the proceedings of the Council, the Annual Business Meeting, and Special Business Meetings. He shall give previous notice to each member of the Council of its meeting and to the general membership of the Annual Business and Special Business Meetings. He shall be the custodian of the Constitution and the By-laws and of the records of the Club. He shall be the compiler of the Annual Report of the Council and shall make it available to the General membership at the Annual Business Meeting. He shall receive and deal with proposed motions to amend the constitution pursuant to Article 23. The Recording Secretary shall be a member of the Executive Committee.

Article 19. Duties of the Corresponding Secretary

The Corresponding Secretary shall deal with the correspondence of the Club as directed by the Council.

Article 20. Duties of the Treasurer

The Treasurer shall be charged with the collection and custody of the moneys of the Club and shall keep a systematic account thereof which shall at any time be open to the inspection of the Council or of the auditors. He shall make disbursements only when authorized by the By-laws or by decision of the Council. He shall submit at each Annual Business Meeting a statement showing the financial standing of the Club. He shall be a member of the Finance Committee.

Article 21. Publications of the Club

(1) *The Canadian Field-Naturalist* shall be issued as directed by the Publications Committee.
(2) Other publications shall be issued as directed by the Council.

Article 22. Expulsion from the Club

Any individual may be expelled from the Club for conduct or activities prejudicial to the well-being of the Club. The procedure shall be as specified in the By-laws.

Article 23. Amendments

Each proposed amendment to this constitution shall deal with only one article, and shall be moved by one member and seconded by another. Written notices of such motions shall be sent to the Recording Secretary prior to June 1 so that they may be published in *The Canadian Field-Naturalist* at least one month before they are to be presented at the Annual Business Meeting the following January. At this meeting, each motion for amendment shall be moved, seconded and discussed separately; each amending motion may itself be amended and carried by a two-thirds majority of the members present.

Article 24. By-Laws

The Council may make By-laws that are consistent with the provisions of the Articles of this Constitution. The By-laws and any amendments thereto shall be published in *The Canadian Field-Naturalist*.

The Ottawa Field-Naturalists' Club By-Laws

(January 1986)

1. Alternate Name

The Ottawa Field-Naturalists' Club shall also be known by the style name, *Ottawa Field Naturalists*.

2. Fiscal Year

The fiscal year of the Club shall start at the beginning of October of any given year and shall end at the end of September of the following year.

3. Disbursements of Club Moneys

Disbursements of Club moneys shall be made by the Treasurer on receipt of properly rendered accounts verified by the Chairman of the Committee concerned or by a Business Manager or as specified by the Council. Disbursements of Club moneys shall be made only by cheque bearing the signature of any one of the three following members of the Council: President, Treasurer, or Business Manager of *The Canadian Field-Naturalist*.

4. Membership Dues

The schedule of dues shall be as follows:

Individual	\$17.00
Family	\$19.00
Sustaining	\$40.00

Life Membership shall be granted upon payment of a single sum of \$400.00.

5. Subscription Fees

The schedule of subscription fees shall be as follows:

The Canadian Field-Naturalist	
Individual	\$17.00
Libraries and Institutions	\$30.00
Trail & Landscape	
Libraries and Institutions	\$17.00

6. General Meeting

The Club shall hold at least two general meetings each year at which the affairs of the Club shall be discussed. One such meeting, the Annual Business Meeting, shall be for the purpose of electing officers and additional members of the Council and for conducting such other business as shall arise.

7. Order and Conduct of Business Meetings

The order of business at the Annual Business Meeting and meetings of the Council shall be:

1. Minutes of the previous meeting
2. Business arising out of the minutes
3. Communications
4. Treasurer's report
5. Reports of Committees
6. New business

The order of business may be changed by a unanimous vote of members present at such meetings. All above meetings shall be conducted according to the Constitution, By-laws, special rules of the Club, and normal parliamentary procedure. In all cases where differences of opinion arise, Bourinot's Rules of Parliamentary Procedure shall be followed. Voting by Proxy will not be permitted at meetings of the Council.

8. Annual Reports

The Chairman of each Standing and Special Committee shall submit a report of the Committee's activities during the year to a meeting of the Council. The Recording Secretary shall prepare an Annual Report at the end of the calendar year which shall include the minutes of the previous Annual Business Meeting and accounts of the activities of each Committee. The Annual Report shall be presented at the Annual Business Meeting and shall be published in *The Canadian Field-Naturalist*.

9. Duties of the Awards Committee

The Awards Committee shall be responsible for nominating deserving members of the Club for Honorary Memberships, Special Club Awards and for awards offered by other clubs and organizations.

10. Duties of the Conservation Committee

The Conservation Committee shall, where feasible and desirable, act in support of conservation of worthy natural areas, with emphasis on the Ottawa-Hull region but also with regard to provincial and national concerns. The Committee shall also keep informed on general conservation problems and policies in other countries.

11. Duties of the Excursions and Lectures Committee

The Excursions and Lectures Committee shall make arrangements for excursions, lectures, and other activities for the education and entertainment of members.

12. Duties of the Executive Committee

The Executive Committee shall propose policy direction, deal with areas which are sensitive or difficult, act as a continuum of thought, deal with emergency matters and call upon other persons for advice when necessary.

13. Duties of the Finance Committee

At the commencement of each fiscal year the Finance Committee shall prepare for the Council's approval a statement of estimated revenues and a proposed allocation of funds for the year. It shall act in an advisory capacity to the Council in all matters concerning investments and disbursements of funds, and any other financial dealings and transactions of the Club.

14. Duties of the Membership Committee

The Membership Committee shall keep the Council informed of the state of the membership. It shall ensure that accurate records of memberships are maintained. It shall act as a liaison between the members and the Council on all matters respecting the conditions of membership.

15. Duties of the Nominating Committee

A Nominating Committee, consisting of three members, shall be chosen by the Council early in the year. The President shall not be a member of the Committee and no Officer of the Club shall be Chairman. The Committee will prepare a slate of Officers and candidates to be elected to the Council at the following Annual Business Meeting. It shall be the responsibility of the Committee to ensure that all members of the Club, whatever their place of residence, have a reasonable opportunity to make nominations. All nominations made to the Committee shall be made in writing, and shall include a statement from the nominee that he or she is willing to serve. No nominations will be received at the Annual Business Meeting, and the Nominating Comittee shall ensure the presentation of sufficient candidates to satisfy the requirements of the Council as laid down in the Constitution.

16. Duties of the Publications Committee

The Publications Committee shall act in an advisory capacity to the Council in all matters pertaining to the publications of the Club. It shall recommend an Editor and a Business Manager for each publication, as required, for appointment by Council. It shall, in consultation with the Editor, appoint Associate Editors for each publication, as required.

17. Special Committees

Special Committees may be formed by the Council and delegated authority for specific tasks. Each Special Committee shall include at least one member of the Council who need not be Chairman of the Committee.

18. Duties of the Editors

The Editor of each publication shall be responsible for the editorial policy, content, and preparation of that publication; shall be a member of the Publications Committee; and shall keep the Publications Committee informed regarding the publication. The Associate Editor(s) of each publication shall assist the Editor.

19. Business Managers

A Business Manager for *The Canadian Field-Naturalist* shall be appointed as specified by the Constitution. In addition, the Council may appoint a Business Manager for any other publication or for the Club itself. The duties of the Business Managers shall be as specified by the Council.

20. Treasurer's Assistant

The Council may appoint a Treasurer's Assistant who shall be responsible solely to the Treasurer. The Treasurer will define the duties of the Assistant in consultation with the Business Manager(s) and the Chairmen of the Standing Committees.

21. Expulsion from the Club

Any individual may be expelled from the Club for conduct or activities prejudicial to the objectives and well-being of the Club, by a two-thirds majority vote of the elected Council, the individual first having had an opportunity to defend himself before the Council prior to the vote being taken.

22. Amendments

An amendment to these By-laws may be adopted at any meeting of the Council, by a two-thirds majority of the members present, due notice embodying a copy of the proposed amendment having been given at a previous meeting of the Council. Any such amendment shall be published in an early issue of *The Canadian Field-Naturalist*.

Book Reviews

ZOOLOGY

Nest Building and Bird Behavior

By N. E. Collias and E. C. Collias. 1984. Princeton University Press, Princeton, New Jersey. xix + 336 pp., illus. Cloth U. S. $45; paper U. S. $16.50.

This book provides a comprehensive treatment of bird nests and nest construction. The authors have drawn on insights from a fruitful 25-year collaboration in field and aviary studies of nest building by weaverbirds (Ploceidae) to produce a summary of the diversity of nest types of all species of birds.

The book can be roughly divided into three parts. The first five chapters introduce the diversity and evolution of nests of birds at various taxonomic levels. Included is a chapter on the role of nests in mate selection, and a brief ethological consideration of the functions of elaborate bowers built by bowerbirds. The next four chapters consider adaptations of nests and nest sites to various environmental demands including weather, predators, parasites, and avian competitors. The last section consists of four chapters on how birds build nests, with emphasis on the influence of ontogeny and hormonal control. Much of this information is based on the authors' pioneering experiments on weaverbird nest construction; it should be mandatory reading for all weaverbirds. The book closes with a chapter on the evolution of gregarious nesting, followed by two useful appendices. The first appendix lists the types of nests built by members of each bird family and the sex involved in construction; the second lists sources of photographs of bird nests including books, films, and photo collections.

On the whole, this synthesis works quite well. The authors have pulled together over 600 references on nests and relevant avian behaviour to identify key similarities and differences among species in how various environmental problems are solved. Examples are illustrated with numerous black and white photographs, and each chapter is nicely summarized. Several general trends emerge, such as the greater incidence of domed nests in passerines (52% of families) than in non-passerines (6%), especially in the tropics. There are also interesting analogies between trends in complexity of weaving of nests and development of weaving in human societies, and the evolution of nests and houses. (There is no connection here with "one of the safest bird nests ever built" — a pair of House Martins in Britain inadvertently used wet cement instead of mud.)

Although this book is very successful as a descriptive summary, the authors occasionally wander into hot water during their evolutionary arguments. Consider the following explanation for clutch size evolution in kittiwakes: "As losses from predators are relatively slight, a clutch of two eggs suffices to replace the population" (p. 46). This is quite an outdated view of natural selection. Except in rare circumstances, individuals are selected to raise as many young (or close relatives) as they can over their lifetimes. There are other instances where the beneficiaries of various adaptations seem dubious. Alexander Skutch's suggestion that a system of helpers at the nest could function as a method of regulating population density certainly requires some critical comment, as does the idea that thievery of nest materials by neighbours may be evolutionarily beneficial because it "discourages slovenly building".

Although the book does not always live up to its evolutionary billing, it compensates as a much-needed synthesis of facts and ideas. By presenting the material in a well-written logical sequence, the authors have produced a highly readable account that represents a major step forward for the study of bird nests and associated avian behaviour.

JOHN D. REYNOLDS

Department of Biological Sciences, Simon Fraser University, Burnaby, British Columbia V5A 1S6

Ocean Birds

By Lars Löfgren. 1984. Croom Helm, Beckenham, England. 239 pp., illus. £ 16.95.

My advertising friends tell me that the first step in selling a product is defining the audience. I find it impossible to decide who the author sees as the audience of this book. Although much of the book is about science, it is presented at a popular level. The information given is far too general for it to be of major value to working scientists. The book is profusely illustrated, mostly by the author's own photographs, and the size and intensity of illustration may justify it as a coffee table book.

It certainly is not a book to aid in identification of difficult-to-separate species, except in a most general sense. Perhaps this book will be suitable for people who have been birdwatching for a few years, and wish to extend their knowledge beyond simple identification and listing. Experienced birdwatchers will probably find that they will not learn much that is new.

The book is divided into eight chapters: evolution and classification, the properties of ocean birds, the species, migration, ecology, behaviour, reproduction, and relationships with mankind. Each chapter is a well-written summary of the current state of our knowledge of sea birds. Important points of explanation, such as the dynamic soaring of albatrosses, are well explained and accompanied by very good supporting diagrams. Indeed, there are many maps, diagrams, tables and similar illustrations to support the points made in the text.

When photographs were not avavilable, the author used black and white drawings to illustrate his point. These drawings, while satisfactory, are a little disappointing in comparison to the fine art work of the maps and other scientific drawings used by the author.

I think I am attracted to birds because of their ability to fly. Sea birds exemplify this power of flight more than any other group. The author's photographs capture the sense of freedom and movement that is inherent in birds of the ocean. I think this is the major pleasure that serious birdwatchers will derive from this book.

Teachers who include birds in their science program will get a wealth of useful ideas for their courses. And, for birdwatchers who have just decided they need to know more than a bird's name, here is a good place to start. If you are a serious scientist, buy the book to look at the pictures, not to read the text (my apologies to *Playboy*).

ROY JOHN

8 Aurora Crescent, Nepean, Ontario K2G 0Z7

The Birds of the Wetlands

By James Hancock. 1984. Croom Helm, Beckenham, England. 152 pp., illus. £13.95.

The author, John Hancock, is obviously a gifted and dedicated amateur ornithologist. This book is about his hobby and, in particular, his passion for herons and egrets. His sense of enjoyment in sharing his hobby percolates throughout the book. Occasionally, the prose becomes a little entangled in itself, but the text is generally clear and straightforward.

The main body of the book is a description of nine of the world's major wetlands. These are the Everglades in Florida; Northern Argentina; the Tana River, Kenya; Bharatpur, India; the Zhalong Reserve, China; the Shinhama Reserve, Japan; Pulau Dua, Indonesia; the Darwin and South Alligator rivers, Australia; and the Coto Donana, Spain. In each case, he describes the site and its history and the birds which live and breed there. He also outlines the problems that each area faces. The natural, political, industrial, and tourist pressures are wide-ranging and amazingly complex. This author is in a good position to evaluate and comment on the importance and future potential for each area, as he has been a keen birder and a world traveller for the last thirty years. It is during this time that wetland destruction has reached a dizzying pace and the author has first hand experience of the effect of the many advancing pressures of civilization. His pleas for conservation while strong are not couched in terms of doom and gloom. Always, they are given with a tone of reason, a degree of humanity and, most importantly, a sense of hope. Because of his global experience, he can relate one wetland to another and put them in a world perspective.

The book is illustrated with the author's photographs. They are excellent. They are clear, crisp and artistic. The birds look alive, the grass looks windblown, and the water looks wet. However, the book designer, Kieran Stevens, has made some frustrating mistakes. For example, both white-naped and red-crowned cranes are illustrated. The splendid photo of the red-crowned crane occupies a full page. The white-naped photograph has been expanded to one and one quarter pages, pushing the text to the left to fill most of the margin. This means the centre line of the book separates the bird's head from its body, giving the bird a disjointed appearance. This unnecessary re-arrangement has been made in several places, presumably for artistic effect! When the book is reprinted, this should be corrected.

The author has included a section on the travel arrangements required to visit these refuges. This is a superb idea and will be of great value to anyone who plans to visit these areas in the next few years. It also makes fascinating reading in itself, being a brief account of the natural, political and logistical problems that confront the traveller. He also adds useful hints on photography and clothing and so on. Indeed, the first chapter is a short description of the

equipment and techniques used with such great success by the author. There is a check list for each area.

This book is worth purchasing for the photographs alone. I say this despite my comments about Stevens' re-arrangements. There are over a hundred photographs of which about a dozen have been "re-arranged". In only about six are the re-arrangements a serious detraction. The text is interesting and enjoyable, the information given is useful, but I'm sure this book will be valued for its magnificent photographs.

ROY JOHN

8 Aurora Crescent, Nepean, Ontario K2G 0Z7

Manitoba's Big Cat: The Story of the Cougar in Manitoba

By Robert E. Wrigley and Robert W. Nero. 1982. Manitoba Museum of Man and Nature, Winnipeg, Manitoba. 68 pp., illus. $6.95 + $1 shipping.

Cougar: an animal of many names, an animal of mystery, an animal of secretive ways, an animal that was at one time found in most of North America but is now restricted to a small portion of its former range. The uniqueness of this animal, its beauty, its strength, its stealth, its agility, its grace combine to fire the imagination of anyone who is interested in nature. This is the largest member of the cat family in Canada, yet few people have been fortunate enough to see one in the wild.

Over a period of many years, 436 sightings of cougars have occurred in Manitoba. Until recently, these sightings met with scepticism. In 1973 a cougar was killed and brought to the attention of people in the Manitoba Museum of Man and Nature. This specimen is the first confirmed record that cougars do in fact inhabit the province of Manitoba. Two noted Manitoba biologists, Drs. Robert Wrigley and Robert Nero, have taken the opportunity provided by this specimen record to tell the story of the cougar in Manitoba; their book *Manitoba's Big Cat: The Story of the Cougar in Manitoba* is the result.

The double column format, in the eight by ten inch size, makes for easy reading. The book consists of ten chapters with a Preface, Acknowledgments, Foreword, and References. Ten colour and 13 black and white photographs, along with sketches by Dwayne Harty, are an attractive addition to the text. The first chapter tells the history of cougar sightings in Manitoba and recounts the scepticism these sightings elicited. Chapter two details the criteria the authors used to accept a sight record. Chapters three through nine report the first specimen record, sightings of family groups, erroneous sightings, vocalizations by cougars, cougar responses to people, cougar dietary habits, and cougar habitat. The final chapter summarizes the author's thoughts on Manitoba's cougars and concludes with a plea for further research on these animals.

The criticisms I have of this book are relatively minor. The eight by ten inch size is not a "standard" size and makes for an awkward book. In a quick reading, I found only one typographic error. With the exception of the authors' published report in 1977, the most current Reference is from 1976. Surely more recent literature on the biology of the cougar has been published in the five years between the technical report and the publication of the book. The one point I found most annoying was the authors' use of both imperial and metric measurements in the reports of the observers. I can understand the rationale behind the interjection of metric measurements but I found it disruptive to my reading. As this is not a "scientific" paper, but rather a popular account of the cougar in Manitoba, either metric or imperial standards of measurement would have been sufficient.

The book is non-technical and is intended for the general public. I believe that it achieves the goal of informing the public about the cougar in Manitoba and the importance of initiating programs to manage this interesting animal. The colour photographs by Maurice Hornocker give the book an extra touch of quality and add to its attractiveness. The sketches by Dwayne Harty are dramatic and exciting. The skill of this artist in giving life to the anecdotal stories is superb. *Manitoba's Big Cat* is an easy book to read. It has beautiful photographs and dramatic drawings and, although regional in scope, would be a welcome addition to the bookshelf of anyone who is interested in nature.

HUGH C. SMITH

Provincial Museum of Alberta, Edmonton, Alberta T5N 0M6

Experimental Behavioral Ecology and Sociobiology

Edited by B. Holldobler and M. Lindauer. 1985. Sinauer, Sunderland, Massachusetts. 488 pp., illus. Cloth U.S. $55.00; paper U.S. $30.

In sharp contrast to the Anglo-American antithesis of nature and humanity, a synthetic life style was espoused by Goethe, developed in continental *Naturphilosophie*, and amid a post-Darwinian world lingers as a pleasant aura in European zoology. For many familiar with his diverse contributions to behavioural biology, Karl VonFrisch (1886-1982) was a prime exemplar of this synthetic life style. This memorial volume is based on a symposium held at Mainz to honour this celebrated biologist who shared the Nobel Prize in Physiology or Medicine in 1973 with Konrad Lorenz and Niko Tinbergen, awarded for their contributions to ethology. After the opening biographical pieces by the two editors, there follow papers by an impressive set of scientists, 17 with addresses in the United States and an equal number from Germany, Switzerland, the Netherlands, and Britain.

These articles are organized into five sections, with taxonomic emphasis on insects, especially social hymenoptera, birds, and mammals. The first section contains chapters on orientation and learning in bees, foraging in army ants, and aspects of optimal foraging theory. In the second section, on communication signals, there are discussions of bee dances, the neural basis of birdsong, primate vocalizations, and a thoughtful general review by Markl on central issues in communicatory processes such as manipulation, information exchange, and cognition. The topics of communication and reproductive behaviour are linked in the third section with the focus on ants, bees, and wasps, and a survey of lek mating systems. The fourth section on social organization considers insects, especially the ergonomics of a colony viewed as a factory within a fortress, and cooperation in birds and in mammals. Problems of physiology and social behaviour, such as temperature regulation, feeding, kin recognition, and stress, are examined in the final section. A subject index is included, but perhaps surprisingly for a volume of this type, there is no bibliography of the publications of VonFrisch. The text illustrations are valuable but unfortunately the small type size used by the printer is too small for easy reading and, like a Mercedes, a volume of this price should be comfortable going.

VonFrisch was noted for the thoroughness, elegance, and realism of his research. The breadth and quality of the material selected for this book justly honours him. By virtue of its function as a memorial volume, this work is not as comprehensive as its title suggests, and is taxonomically very selective. The form of the chapters ranges from research report to critical review, and their content encompasses topics in physiology, genetics, ethology, ecology, and evolution. Several themes run through many of the chapters, with emphases on the importance of choosing suitable test species for problems of interest, of a detailed understanding of the underlying physiological mechanisms, especially of sensory systems, of careful ethological and ecological analysis, and of resolving contradictory conclusions. While the increasing confluence of ideas with animal psychology does not receive explicit attention, psychological phenomena such as the overlearning reversal effect and stimulus generalization appear in various places. The viewpoint of social colonies, such as beehives, as superorganisms, prominent in the writings of early researchers and more recently unpopular, interestingly appears in several chapters. A sanguine E.O. Wilson in his offering on principles of caste evolution argues that "the time may be at hand for a revival of the superorganism concept".

Similarly, the nature of animal cognition, in its various aspects such as intention and empathy, is discussed by several authors, and is central to the epilogue by Donald Griffin. Continuing his previous treatments of this subject, Griffin mixes valid points about the richness of animal communication and the parsimony of assuming continuity of processes across species with murky mutterings about the scientific validity of mental concepts. It is well that he points out that VonFrisch might not "agree with all or even with any of what I am suggesting". This finale notwithstanding, the book contains valuable material.

PATRICK COLGAN

Biology Department, Queen's University, Kingston, Ontario K7L 3N6

Milkweed Butterflies

By P. R. Ackery and R. I. Vane-Wright. 1984. British Museum (Natural History) — Comstock, Cornell University Press, Ithaca, New York. 425 pp., illus. U.S. $75.

The large, orange and black Monarch is one of the best known butterflies in North America. It has been seen in migration by many, and its inedible (to birds) nature in comparison with the similar but edible Viceroy is often referred to in biology classes. It is the only Canadian member of the essentially tropical group of 157 species of "Milkweed Butterflies".

The present book is "a reference work and a source of old and new ideas about many aspects of the . . . natural history" of the species of the subfamily Danainae of the butterfly family Nymphalidae. The allocation of 55 pages to cladistics, 35 to biology, 55 to co-mimicry and faunistics, 13 to identification keys, 72 to a taxonomic and biological catalogue, 38 to a bibliography, and most of the rest to figures, plates and indices shows a strong and thorough emphasis on taxonomy and distribution.

The taxonomy of many species, including our own Monarch, is clear-cut in comparison with that of a number of large tropical genera where distinctions are slight. The cladistic analysis involves an assessment of the currently accepted species on the basis of 226 characters. This conservative approach yielded results which generally confirmed most traditional groupings but it also gave clarification in the more difficult complexes.

This reviewer found the chapter on biology to have especially interesting accounts on scent organs, chemical defenses, genetics, ecology, and migration. These topics are of more than passing interest to many and should have been expanded.

Part of the mimicry concept is that a species that is edible to a predator or group of predators may evolve so that it becomes similar in appearance to distasteful species that their predators avoid. This concept is examined in detail, as Milkweed butterflies are generally avoided by predators and often have "edible" mimics.

The taxonomic and biological catalogue is a mine of information as, under each species, it states in brief terms and/or refers to the literature available on a wide range of topics. The reader will be amazed at the number of articles that deal with our local species, the Monarch.

The book has been carefully proofread and is remarkably free of errors. The twelve colour plates are of high quality but the 103 pages devoted to line drawings and black and white photos, though good, could have been cut in half by reducing the size of the illustrations.

Canadian field-naturalists will find F.A. Urquhart's 1960 book *The Monarch Butterfly* to be an excellent source on that species. The present book updates information on the Monarch and covers all other Milkweed butterflies. It presents what has been done and provides an excellent basis for further research.

CHARLES D. BIRD

Box 165, Mirror, Alberta T0B 3C0

Winter Ecology of Small Mammals

Edited by Joseph F. Merritt. 1984. Special Publication No. 10, Carnegie Museum of Natural History, Pittsburgh, Pennsylvania. ix + 380 pp. U.S. $45.

This work is a collection of 37 papers presented in October 1981 at a colloquium sponsored by the Carnegie Museum. The papers represent six nations as follows: USA (20), Canada (7), Finland (6), USSR (2), Sweden (1), and Czechoslovakia (1). Five papers present overviews of snow and small mammals (Pruitt), small mammal evolution in northern regions (Hoffmann), subnivean sampling (Schmid), light penetration through snow (Marchand), and plant growth under the snow (Salisbury). Also present are review articles on the following topics: winter tissue changes (Quay), winter reproduction (Hansson), *Peromyscus* reproduction and survival (Millar), group nesting (Madison), winter aggregations (West and Dublin), and subnivean food chains (Aitchison). Overall, the above-mentioned papers are well-written and informative and represent the strength of the book.

The remaining papers, primarily presenting field data on shrews, voles, and mice in northern regions, vary considerably in quality and many have serious deficiencies. These include faulty logic, unsupported conclusions, the notion that correlation means causality, imprecision, bad grammar, and inappropriate form for a scientific article. The European papers seem especially prone to these problems.

Because of problems with many of these research papers, it is difficult to make an overall recommendation concerning this text. Certainly, the volume

succeeds in bringing together the work of those pursuing winter ecological research involving small mammals, primarily by workers specializing in mammals, but botanical and entomological papers are also included. One can also easily obtain a clear idea of areas where further research is needed from this book.

DAVID A. LOVEJOY
Department of Biology, Westfield State College, Westfield, Massachusetts 01086

A Guide to Field Identification of Birds of North America

By Chandler S. Robbins, Bertel Bruun, and Herbert S. Zim. 1983. Expanded, revised edition. Golden Press, New York. 360 pp., illus. U.S. $7.95.

The "Golden Guide", as this book is popularly known, was for many years widely considered the best North American bird field guide. In April 1980, after the Golden Guide's only real competitor underwent a thorough revision, it became much less clear which was the better guide. When the birding community learned of the upcoming release of a revised and expanded version of the Golden Guide, expectation and excitement started to mount.

In many respects the revised Golden Guide proved to be a letdown. The expansion amounted to only a 7% increase in the number of pages and the revisions were not as thorough as they could have been. Indeed, after briefly flipping through the new edition one would be hard pressed not to think that it was the original. The revised edition's predecessor broke new ground; those expecting the revised edition to be as innovative were disappointed.

While the revised edition lacks a pioneering spirit, it makes great strides in catching up the 17 years which had severely dated its predecessor. Those 17 years have seen a tremendous growth in our field knowledge of birds. There are many bird species in the revised guide which aren't in the original. These additions are the result of the expansion of birds' ranges into North America, the increase in accidental strays which now wander to North America, the recent release or escape of non-native species, and the re-classification of some subspecies into species. In order to accommodate all the new species, additions were either squeezed into the existing format, resulting in over-crowding, or new plates were prepared. The juggling, cutting, and pasting was very poorly done. Never does an updated or new plate match the calibre of the original guide. The doctored plates are the major disappointment of the revised edition.

The revision seeks to incorporate new knowledge and update nomenclature and taxonomy. While it is not completely successful in incorporating all the new knowledge, the text, on the whole, has undergone a fair amount of revision. For some species there have been extensive revisions, for others none at all. The range maps have been updated. They are now easier to read, but, like the text, not as thoroughly updated as they could have been. As for nomenclature, the revision is completely up to date, as it uses the latest American Ornithologists' Union changes. The revised edition's sequence is pretty much that of the original; its only concession to the many recent taxonomic changes is to have its table of contents in taxonomic, rather than page-number, sequence.

The Golden Guide has retained its format of range maps, sonagrams, and text facing the plate. While the text and maps are more useful than the previous edition's were, the sonagrams are just as unusable as ever. The revision has updated the handy 12 page introductory section of the original. The type-face has been changed, not for the better, to a fancier and lighter script. The revised edition is handier than the original.

How does the revised Golden Guide compare to the other eight or so North American field guides? The Golden Guide is not the best. A newcomer, released the same year as the revised Golden Guide, is by far the superior guide. The Golden Guide is a strong contender for the position of second best. As birders invariably end up building up collections of bird books, this reviewer has no qualms in recommending the revised Golden Guide. While *Birds of North America* may have been superseded in the field, it is still a book to have in one's collection.

STEPHEN T. GAWN
1000 Silver Street, Apartment 22, Ottawa, Ontario K1Z 6H6

An Annotated Bibliography of Literature on the Spotted Owl

By R. W. Campbell, E. D. Forsman, and B. M. Van Der Raay. 1984. Land Management Report Number 242. British Columbia Ministry of Forests, Victoria. 115 pp. $7.50.

The three authors were working independently on Spotted Owl (*Strix occidentalis*) bibliographies when they decided to pool their resources in order to produce the best possible compilation. Their wise decision has resulted in an excellent product.

Almost 600 citations are listed alphabetically by author and are numbered sequentially. These citations are current to 1983. Included are many unpublished internal reports of various agencies. While these sources may be difficult to locate and are usually omitted in comparable works, the authors are to be commended for including them here; at least we now know that such information has been drawn together. All citations considered by the authors to be particularly significant and/or in need of qualification or correction are annotated. This is very useful and one might wish that they had broadened the annotations to include *all* entries. Such citations as "110. Cogswell, Howard L. 1956. The Spring Migration : Middle Pacific Coast Region. *Audubon Field Notes* 10(4): 358–363" *presumably* includes Spotted Owl information, but the nature of these data is not specified.

One of the most useful features of the report is the cross-referenced index at the back of the volume. Within 39 categories, such as Banding, Behaviour, Parasites, and Predators, reference is made to the citation number of each paper/study that includes information that is pertinent to this area.

The list appears to be quite complete and includes many citations not found in Clarke et al. (1978. Working bibliography of Owls of the World. National Wildlife Federation, Washington) and it is certainly easier to extract citations from the present report than it is from the latter. They have missed (as have other bibliographies) John Macoun's classic *Catalogue of Canadian Birds* (Volume 2 (1903) is the appropriate volume). Although his information is repeated in Macoun and Macoun (1909), the 1903 report may constitute the first mention of the Spotted Owl in Canadian scientific literature and is of historical interest at least. Another omission is the article discussing the (slim) chances of seeing one of these rare animals in Canada (G. Bennett. 1982. The Spotted Owl . . . Does it or Doesn't it? Birdfinding in Canada 2(3): 1–3). These are minor problems, however.

There are only a few minor typographical/spelling errors in the text. It is a typewritten text, presented in clear, well-spaced and easily read type. It is firmly paper-bound; my copy stood up well to the rigours of the review process. It is a practically and solidly produced volume.

The authors have produced a most useful contribution to the literature of this rare species in particular and to owl literature in general. It will be of great help to those interested in studying the Spotted Owl and/or related species. Let us hope that comparably successful bibliographies are produced for other Canadian owl species.

DANIEL F. BRUNTON

2704 Marie Street, Ottawa Ontario K2B 7E4

The Florida Scrub Jay: Demography of a Cooperative-Breeding Bird

By Glen E. Woolfenden and John W. Fitzpatrick. 1984. Monographs in Population Biology 20. Princeton University Press, Princeton. xiv + 406 pp., illus. Cloth U.S. $45; paper U.S. $14.50.

An encounter with a group of Scrub Jays can be one of the highlights of a birding trip to Florida. The species is just as fascinating on closer acquaintance, with its communal breeding system that has become well-known through the papers of the authors and their colleagues.

Their studies began in 1969, and this monograph presents a comprehensive analysis of their data from the decade that followed. It is a remarkable work from several points of view. For one, it's readable, a feature not always characteristic of demographic studies. A ten-year study of a population of wild, free-living birds is an achievement in itself. In this study every jay on the 340–400 ha study tract was counted monthly, all birds were individually marked, and the authors feel they were successful in finding virtually every nest — some 400 in all — on the study area during the 1970s.

The species — a conspicuous bird that occupies open habitat and is easily tamed — is an ideal one for such a study. The investigators freely use this characteristic to facilitate their work. Instead of having to look for their birds, they found that a few chopped peanuts assure that the birds come to them. In most locations such a strategy could have seriously prejudiced any study. Here, the Archbold Biological

Station provides a controlled environment, as well as the long term habitat management which is so essential to a long-term undertaking of this kind.

Florida Scrub Jays are highly sedentary birds restricted to areas of open oak scrub. This habitat is very localized in Florida today, and is rapidly becoming scarcer. Virtually all suitable habitat is continuously occupied by jays, which defend large territories throughout the year. Typically each territory fulfils all the needs of its resident group of jays, although only a single pair usually breeds there. The other residents — and most territories have one or more helpers — are usually, but not invariably, progeny of the breeding pair. In these groups males dominate females, the breeding birds dominate helpers and older birds dominate younger siblings. The helpers do help — in territorial defense, but also in raising the young. Pairs with helpers raise more young than pairs alone.

The authors argue convincingly that in an environment where all suitable habitat is continuously filled by long-lived birds, it is more advantageous for a young bird to "wait its turn" to breed in familiar surroundings than to risk dispersal. Inbreeding is avoided by females dispersing, but males stay home. Eventually they acquire breeding territories of their own, either by replacement or by territorial "budding" — a process where a group of jays expands the size of its territory, a portion of which is then ultimately taken over by a young bird.

One of the current controversies in population biology today centres on the advantage to the individual of "helping-at-the-nest". Many authors favour a kin selection explanation, where the helper is seen as assisting close relatives, and hence helping perpetuate some of its own genes. While the present authors recognize the importance of kinship, they argue that the present system would evolve "even in the absence of the indirect, kinship components to fitness".

The study avoided manipulative investigations such as removal of jays, although a fascinating epilogue chronicles a sudden collapse of the breeding population in 1980 which resulted in a remarkably rapid return to its former stable level — a result wholly in keeping with the authors' predictions. Letting nature create the experimental conditions results in small sample sizes at times, but the advantage of working with a stable, natural population clearly outweighs this drawback.

The text is interspersed with numerous figures and tables — enlivened by occasional vignettes of jay activity relevant to the topic of the figure — which provide excellent support to the lucid text. The final chapter presents a reasoned discussion on the evolution of Scrub Jay sociality.

This is an important contribution to population biology. It will be of interest not only to workers in the field, but also as a readable introduction to one of the central topics in ornithology today. For the general naturalist, who should not be inhibited by the occasional algebra and multitude of tables, it's a well-written, thoughtful account of a fascinating subject.

CLIVE E. GOODWIN

45 LaRose Avenue, #103, Weston, Ontario M9P 1A8

BOTANY

Microfungi on Land Plants: An Identification Handbook

By Martin B. Ellis and J. Pamela Ellis. 1985. Macmillan, New York. 818 pp., illus. U.S. $75.

An excellent identification manual, this volume will greatly facilitate the naming of specimens of microfungi. Microfungi are those fungi whose fruiting structures (i.e. those tissues or cells that produce the spores) are at most several millimeters (mm) in extent. Identification of these fungi generally depends on a knowledge of the size and shape of the spores and associated structures which are typically 0.005-0.060 mm in size. Thus a microscope which magnifies 400 to 1000 times is essential equipment in the study of microfungi.

A certain knowledge of the fungi and their taxonomy is, understandably, presumed. For example, the names of major taxonomic groups (Discomycetes, Hyphomycetes, Coelomycetes and Basidiomycetes) are neither defined nor keyed. Unfortunately in some instances the reader is presumed to have quite an in-depth understanding of the genera. For example, the chapter on *Plurivorous Leaf-litter Fungi* lacks keys to the 15 genera of Discomycetes and the reader is expected to know the differences between *Betulina, Botryotinia, Dasyscyphus*, etc. I feel this is expecting too much, since it requires the use of different books to identify these taxa.

This handbook is well-organized, quite comprehensive (containing 3300 fungi), and with 2125 species accurately illustrated by drawings showing habit and critical microscopic features. The 579 pages of text are divided into nine chapters, with titles such as *Plurivorous Wood and Bark Fungi, Fungi Specific to Trees, Shrubs and Woody Climbers*, and *Fungi Specific to Grasses*. Each page carries a header which is the chapter title, a very useful feature. Within the chapters on plurivorous fungi, the fungi are arranged by fungus group (e.g. Discomycetes, Other Ascomycetes) and each group may have a key to the genera. Keys to species are provided if the genus has numerous species. The chapters on fungi specific to certain plant groups (e.g. *Fungi on Ferns, Horsetails and Clubmosses*) have the host plant genera presented in alphabetical order. Within each host genus the fungi are arranged in convenient, often taxonomic, groups.

Each fungus entry contains the Latin or scientific name of the fungus, followed by a description of the pertinent macro- and micro-features, and finally comments are included on host species, the host tissues affected, season of fruiting, and occurrence. The text is concluded by a helpful glossary containing about 230 technical terms. Two indices are provided, one for fungal names and the other for host genera combined with common names for the hosts.

There is no book on Canadian, or for that matter North American, microfungi that has such a broad scope. Although based entirely on microfungi in the British Isles, the book will be very useful elsewhere because many of the species are widespread. The book provides a quick means of eliminating a large number of possibilities, if the specimen under study is not a fungus treated in the handbook. For example, of the 118 names on page 794 of the index, 30 percent have been reported in Canada. The actual number of fungi on that page which are reported from Canada is closer to 50 percent because Canadian reports preferred a different generic name.

Everyone dealing with the microfungi will want to have a copy of this book available for quick reference. The literature on microfungi is widely scattered and this book will make the work of many of us much easier.

J. GINNS

Biosystematics Research Centre, Agriculture Canada, Ottawa, Ontario K1A 0C6

Wetlands of the United States: Current Status and Recent Trends

By Ralph W. Tiner, Jr. 1984. U.S. Fish and Wildlife Service National Wetlands Inventory. U.S. Superintendant of Documents, Washington. 59 pp., illus. U.S. $3.

This concise, well-referenced and complete report on the current status of the United States wetlands, a publication of the Fish and Wildlife Service, is a valuable and accurate reference. Tiner begins the booklet with the sobering fact that between 1950 and 1970 the U.S. had a net loss of 9 million acres of wetland, 87% of this loss due to agricultural development; in addition, population and agricultural trends point to pressure for more wetland conversion. Wetlands are defined as transitional habitats where the water table is at or near the surface with periodic flooding, the "degree of flooding or soil saturation and presence of wetland plants and/or hydric soils" being determining factors. Wetlands are classified as marine, estuarine, riverine, lascustrine, and palustrine; the report focuses on estuarine and palustrine wetlands because they are the most abundant types. The value of wetlands for fish and wildlife habitat, for the maintenance of environmental quality and for economic reasons (flood protection and groundwater recharge) is also surveyed.

The rest of the report is an extensive discussion of the trends that Tiner foresees for wetlands in the U.S. Recent gains (beaver activity, construction of lakes, reservoirs and farm ponds) have been offset by enormous losses due to agricultural drainage, urban development, bottomland hardwood forest conversion to farmland, peat mining, and the rise of the sea level along the gulf coast. To put this in historical perspective we are told that California has lost over 90% of its original wetlands, Iowa 95%, and Illinois has lost 98% of its bottomland swamps: these are just a few examples. The Wetlands Act of 1973 has dramatically decreased the rate of wetland loss, but Tiner sees a number of problem areas. He calls them areas of "greatest jeopardy". They include the estuarine wetlands of the U.S. coastal zone, Louisiana's coastal marshes, Chesapeake Bay's submerged aquatic beds, the Prairie Pothole region's emergent wetlands, and the western riparian wetlands. These areas are discussed in detail.

Future pressure on wetlands will come from population growth, growth of suburban population centres, and increased conversion to agricultural use. Protection of wetlands can occur through federal and state acquisition, federal and state regulation which Tiner feels needs strengthening, and tax incentives.

The report ends with a summary of recommendations for government and private individuals and says "with over half of the wetlands in the conterminous U.S. already lost, it is imperative that appropriate steps be taken to protect our remaining wetlands." I recommend this booklet to anyone concerned with or about wetlands.

CAROL B. KNOX

Science Department, Northfield Mount Hermon School, Box 76, Cutler Science Center, Mount Hermon, Massachusetts 01354

Type Specimens of Bryophytes in the National Museum of Natural Sciences, National Museums of Canada

By Robert R. Ireland and Linda M. Ley. 1984. Syllogeus No. 47. National Museums of Canada, Ottawa. 69 pp. Free.

The Bryophyte portion of the National Museum of Canada holds some 204 000 specimens of mosses and hepatics, and is the largest in Canada (Vitt, D. H., S. R. Gradstein, and Z. Iwatsuki. 1985. Compendium of Bryology. A World Listing of Herbaria, Collectors, Bryologists, and Current Research. Bryophytorum Bibliotheca 30. 355 pp. J. Cramer, Braunschweig). Historically, it contains the herbarium of John Macoun, one of the most important early collectors of Canadian bryophytes.

One of the most significant aspects of taxonomic research is determining the correct allocation of the names of organisms. Typification of these names is the necessary process in accomplishing this and the location of appropriate type specimens is one of the initial steps in the typification process. In recent years, a number of publications have been written cataloguing the type specimens housed in particular herbaria. These invaluable research sources include indices to such important herbaria as *Die Laubmoostypen des Herbariums Hamburgense* by K. Walther and G. Martienssen (published by the Institut für Allegemeine Botanik der Universität Hamburg, 1976).

With the publication of Robert Ireland and Linda Ley's catalogue of type specimens in the National Museum, Canada's most important and largest bryophyte herbarium has an up-to-date inventory of our most significant taxonomic specimens. This catalogue consists of an alphabetic listing of 848 moss and 86 hepatic taxa. Included are the authority, literature citations, kind of type, locality information, collector name or date, CANM accession number, and currently accepted name of each taxon. The type specimens from the Macoun herbarium are recorded separately. The authors have done a careful job and I found few typographical errors. The format is excellent. The inclusion of label data for each type specimen is especially useful, as monographers can check these data against the protologue when perusing the material that they need to examine. The paper quality and photo-offset print are both excellent. The large page size allows easy use of the publication. The authors are to be complimented on an excellent presentation. More of this type of bibliographic cataloguing is needed, in order for taxonomic research to be efficiently carried out in the 20th century. This publication is available at no charge, from the National Museum.

DALE H. VITT

Department of Botany, University of Alberta, Edmonton, Alberta, T6G 2E9

Trilliums of Ontario

By James S. Pringle. 1984. Royal Botanical Gardens, Hamilton Technical Bulletin No. 5. Third edition. 27 pp.

This revised edition of the *Trilliums of Ontario* has been produced in recognition of Ontario's bicentennial. It is attractive and informative. Sections dealing with the history of the selection of Ontario's floral symbol, general aspects of the botany of the genus (morphology, distribution, ecology, and cytology), descriptions of the native species (including discussions of ecology and distribution), hybrids, variations and aberrations, where to see trilliums, conservation, traditional and historical uses, and cultivation form the text of this publication. Many readers will find the explanation of the nature and cause of the "floral greening" aberrations commonly found in the White Trillium (*Trillium grandiflorum*) to be interesting, and references will lead the reader to more specific and detailed discussions of the subject.

Whenever a publication is revised, one expects to find improvements, and perhaps expansion. This new edition incorporates colour photographs on the cover as well as throughout the text. New larger illustrations have replaced those used in the second edition. Although the texts of the two most recent editions are relatively similar (updated with modern references in the new edition), the organization of chapters differs somewhat. An interesting addition in this edition is a map of the world distribution of the genus *Trillium*. A range map has been included for *T. grandiflorum*, as well. Unfortunately, the other three species native to Ontario have not been mapped. Dot distribution maps would have added considerably to the usefulness of the booklet for field botanists and phytogeographers. For example, the discussion of outlying stations of the Painted Trillium (*T. undulatum*) along Lake Erie could have been enhanced and clarified with the addition of a range map for this species.

There is one section in the booklet that, in my opinion, serves no useful purpose ("Where to See Trilliums in Ontario"). I say this mainly because it is almost impossible to provide sufficient information on enough different sites to satisfy botanists and wildflower enthusiasts in all parts of the province. Here again, the inclusion of up-to-date range maps for all taxa, in conjunction with the ecological information already included in the text, would have provided more useful information on how to find the different species of *Trillium*.

Several features from the second edition have been omitted from the new one, presumably to save space and to reduce costs. Unfortunately, these omissions reduce the comprehensiveness of the booklet. The table of contents, drawings of leaves, and a chromosome photograph have been omitted. It is a bit surprising that no key to species has been included in this or previous editions.

In spite of the omissions that I have noted above, the booklet contains a lot of useful and interesting information on our native Trilliums, and it is certainly worth acquiring. I would hope, however, that these comments will be considered and incorporated in the next revision.

WILLIAM J. CRINS

Department of Botany, University of British Columbia, Vancouver, British Columbia V6T 1W5

ENVIRONMENT

Lob Trees in the Wilderness

By Clifford and Isabel Ahlgren. 1984. University of Minnesota Press, Minneapolis. xii + 218 pp., illus. Cloth U.S. $29.50; paper U.S. $12.95.

This book provides a fine, perceptive exploration of human impact on wilderness. The wilderness is the Boundary Waters Canoe Area of northern Minnesota, and "lob trees" are used as a poetic way to link the results of historical and ecological research in this setting. The book is set apart from more scientifically satisfying works because it communicates directly to the human level that generates wildland impact. Yet the authors' scientific roots are evident to one who "scuffs about the leaf-litter", with the result that I see great hope for their message getting through to the interpreters and managers of wildland parks.

The authors are thorough historians and thorough ecologists. They provide the reader with details of careful observations of forest succession and composition, woven within the readily recognizable fabric of the Great Lakes – St. Lawrence forest and its landscape history. The wonderful series of historical photos they have collected is an education in itself, and certainly confirms in my mind that the mighty "lake forest pines" extended west of the Lakehead. The main body of the text is composed of seven theme topics, prefaced by an Introduction and suffixed by Conclusions. The themes in sequence are *Flora, Forest Fire, Presettlement Forests, Early Inhabitants, Pine Logging, Pulpwood Logging*, and *Recreation and Preservation.*

This is a well illustrated book that provides rewarding reading. The book is built to be carried in hand or pack, as one travels through the lands under discussion; after all, lob trees have guided many through the wilderness.

RICHARD L. W. BOBBETTE

8 Cumberland St., Main Floor, Barrie, Ontario L4N 2P4.

MISCELLANEOUS

Evolution: The History of an Idea

By Peter J. Bowler. 1984. University of California Press, Berkeley and Los Angeles. xiv + 412 pp., illus. Cloth U.S. $29.95; paper U.S. $10.95.

Charles Darwin's historic voyage on H.M.S. *Beagle*, his visits to South America and the Galapagos Islands, and his eventual publication of his theories in *On the Origin of Species* in 1859 have long been familiar events to scientists, historians and philosophers of science. Evolution has also been taught in high schools and universities and explained to the layman by popularizers of science. Practising scientists have long ago incorporated evolutionary theory in their thinking, and a whole "Darwin industry" has grown up among historians and philosophers of science, with well over 100 publications interpreting early influences on Charles Darwin, his development as a scientist and his impact on our understanding of *how* life evolved.

During the last decade the so-called "creationist controversy" in the United States brought the whole idea of evolution into the limelight again, and several books have been published on the fundamental belief of creationism. Other theories, proposing modern alternatives to Darwinian evolution, have also been discussed in print and in the media. The resulting confusion of theories has caused particular difficulties for students and teachers of biology and the history of science, while the layman's attempts to make sense of these conflicting theories have been doomed to frustration.

In *Evolution: the history of an idea*, Peter J. Bowler aims at helping the non-specialist by charting the history of the *idea* of evolution, from early theories of the earth to modern debates concerning evolution. He discusses historical issues and viewpoints in studying evolution, and "taking nothing for granted" (that is, no previous knowledge or expertise on the background or major features of evolutionary theory) he sets out to discuss concepts, cosmogonies, and geological theories. In a particularly important chapter on "Evolution in the Enlightenment" the author treats such central issues as "design", the problem of change, chain of being, the Linnean system of classification, new theories of "generation", Erasmus Darwin, and J. B. Lamarck whose ideas came closest to the modern concept of "organic development." Following this, Bowler leads the reader through changing views of man and nature in France, Britain, and Germany, the interrelationships of geology and natural history from 1800 to 1859, and the influence of fossils and their interpretation on natural history. He dispels the notion that "Darwinism was in the air" and that its emergence in the 1850s was inevitable. He stresses that Charles Darwin followed a new direction challenging fundamental beliefs by offering a new theory which was basically incompatible with arguments centered on design.

In three central chapters, the author discusses the origins of Darwinism, Darwinism and the scientific debate, and Darwinism and moral and religious problems. In the first of these Bowler warns of pitfalls of following either an exclusively externalist approach (concerned only with outside influences on Darwin) or a solely internalist viewpoint, which may lead to an evaluation of Darwin's contribution judged by a modernized version of the theory of evolution. He also reminds us that Charles Darwin was a *naturalist* and "any effort to understand him, that does not take this view into account will fail" (p. 143). The rest of the chapter deals with Darwin's education, his voyage on H.M.S. *Beagle*, the years immediately following his return to England (1836-39), the development of his theory, and A. R. Wallace and the 1859 publications of *On the Origin of Species*. In the next two chapters details and arguments on both scientific and religious-moral difficulties, which raged for several decades, are discussed in sufficient detail to make the reader aware of problems of interpretation by scientists, theologians and philosophers on both sides of the Atlantic. These chapters make a good transition to 20th century problems and theories. "The Eclipse of Darwinism" (only one chapter in this book, but the subject of a 1983 book by Bowler) explains alternatives to Darwinism, such as Neo-Lamarckism, orthogenesis, and Mendelism, topics of great interest to our understanding of the theoretical beliefs of many early 20th century experimental biologists. This brief discussion leads the way to other issues of great importance, such as Social Darwinism, Eugenics, evolution, and race.

The rise of population genetics and its place in modern evolutionary synthesis would have made a logical climax to any book on evolution before 1970. However, discussion concerning the relative merits of group versus individual selection led to concepts of kin-selection, altruistic behaviour, and the emergence of sociobiology with its new theories of animal behaviour and controversial implications for human nature. Bowler discusses sociobiology and other modern debates, of which Creationism is best known. Although early in the 20th century creationists attempted to forbid the teaching of evolution in American high schools, by the 1970s they were

beginning to demand equal opportunity to present their views to high school students. The media made much of these issues, and the creationist debates overshadowed other alternatives to the modern evolutionary synthesis, such as the "Punctuated Equilibrium" model proposed in the early 1970s by Niles Eldredge and Stephen Jay Gould.

Evolution: the history of an idea was written as a textbook for teachers and students in the history of science. It is much more than that. Informative, concise, up to date in references, it is a superb *field guide* to this important but often confusing subject.

MARIANNE GOSZTONYI AINLEY

Department of History, McGill University, 855 Sherbrooke West, Montreal, Quebec H3A 2T7

Proceedings of 1981 Workshop on Care and Maintenance of Natural History Collections

Edited by Daniel J. Faber. 1983. Syllogeus No. 44. National Museum of Natural Sciences, Ottawa. 196 pp., illus. Free.

Museums have experienced several decades of unprecedented successes in their exhibition galleries. More recently they have shown increasing concern for their collections, long neglected skeletons in the closets of many museums, which are not nearly as successful as their public showcases would suggest. The publication reviewed here is a milestone on the national museum scene since it results from a gathering of people who work with collections from Victoria to Halifax. It documents some national concerns along with some local examples of improved techniques needing national distribution.

Large collections of biological specimens are important for many reasons and probably always will be. Since accurate identifications of species often depend on comparisons with specimens, and it is worth the biologist's good reputation to know accurately what organism he is talking about, this continuing public need alone ensures the future of museum collections. Accurate identifications keep scientists and others from wasting time and money studying, say, a population of species alpha which later turns out to be not species alpha at all, but instead a mix of the three superficially similar species beta, gamma, and delta. The biological sciences need good collections simply to continue being worthy of the term "sciences". Imagine a science with scientists who don't know what they are talking about.

This book is valuable for what it contains, and perhaps also for what it does not. It has 28 papers and abstracts (the latter without papers) which have the predictable unevenness typical of a collection brought together by a general call for conference participants. The book has a forward (*sic*) by Louis Lemieux and a preface by Daniel Faber and Gerald Fitzgerald, both giving useful overviews putting the specific concerns of the workshop within the scope of Canada's natural history collections and their national problems. For those who are wondering, the term "natural history" includes both the biological and geological sciences, as does "natural sciences".

Some papers on the care of collections report on specimen preservation, the most notable addressing new or better techniques for improved appearance, easier preparation, or safer storage. Maintenance matters are dominated by timely reviews of procedures and benefits from using computers to manage, retrieve, and manipulate information about collections. From my limited view, among the more innovative papers are those on preserving and coating whole brain specimens, keeping insect larvae in gylcerine, preventing light damage to wet specimens by storing jars in small boxes, storing dried insects loose and in bulk in gelatin capsules, and restoring dried up wet specimens.

Much is not in the book which might be, and perhaps should be, which is to say that the topic is a large one and more of such workshops are needed. In my view major problems confronting Canada's biological collections today were missed in the process of collecting together volunteer speakers. One is the problem of placing insect deterrents and poisons as constant safeguards among dried specimens to prevent damage from insects, and fogging with poisons to combat insect outbreaks in buildings. This problem boils down to: "That which is unhealthy for insects seems to be unhealthy too for people in the vicinity". Another is that, in this time of miraculous accomplishments by technological man, museums seem unable to find an inexpensive way to seal specimens in jars containing fluid preservatives to avoid the need for topping up periodically to save the specimens. Related to these is a major concern for biological collections on some university campuses, which are in some danger as biological foci there turn largely toward chemistry and the cell, leaving the professor concerned with entire animals a rare and endangered species. When no one cares about campus collections they often just disintegrate. The danger increases as many campuses now adjust yet again to severely decreased budgets. For these and other

reasons the proceedings of this meeting indicate that much is still left to consider and discuss.

The book has two appendices, one containing a selected bibliography with 89 entries on the topic of the meeting, and the other giving returns from questionnaires sent across Canada to 500 institutions housing biological collections. From the latter there were 147 replies, each one showing a desire to meet periodically to learn from others doing similar work. So when is the next meeting?

YORKE EDWARDS

663 Radcliffe Lane, Victoria, B.C., V8S 5B8

Dear Lord Rothschild: Birds, Butterflies, and History

By Miriam Rothschild. 1983. ISI Press, Philadelphia. xxiv + 398 pp., illus. U.S. $29.95 in the U.S., Canada, and Mexico; U.S. $32.95 elsewhere.

This is a gracefully written book about an engaging and unusual member of the famous Rothschild family, who made his mark not in the field of finance, but as a natural historian of considerable distinction. In the forty-odd years from 1889 until the early 1930s, the world's largest private collection of zoological specimens was created and maintained in the village of Tring, England, some 25 miles northwest of London, by the brilliant and eccentric Lord Lionel Walter Rothschild (1868-1937). Lord Rothschild was a very private, shy and reticent person, whose only close friend appears to have been his fond mother, though he had a number of professional colleagues. A serious speech impediment made any extensive public speaking impossible. He was, the author tells us, both creative and childish, a man of massive contradictions, yet exceptionally able and devoted to his collections. These ultimately consisted of nearly three million specimens, mainly lepidoptera and beetles, though nearly ten percent of this total was bird skins. The decision to sell the bird specimens toward the end of his life created something of an international furore in zoological circles.

Early in his collecting career, Rothschild persuaded two exponents of what later became known as the new systematics, Ernst Hartert, then one of the world's leading ornithologists, and Karl Jordan, an equally eminent entomologist, to direct the research efforts at Tring. They in turn provided a high calibre of guidance for a number of younger colleagues who were generally eager to work from time to time in the yeasty atmosphere of disciplined scholarly effort at Rothschild's Museum. Colleagues later marvelled at how much Hartert, Jordan and others associated with Tring were able to accomplish, given the Museum's meager annual budget of several thousand pounds.

Rothschild's finances were always complex. Admittedly poor at managing money, he relied upon his parents and his younger brother Charles for guidance in this area and, following his brother's untimely death, upon the latter's very capable widow. Both Hartert and Jordan accepted much less in salary than they could have expected to receive elsewhere. However, the expeditions mounted to various parts of the world under their leadership were well managed and productive of important discoveries in zoology. The outstanding series of publications produced by Hartert, Jordan and their colleagues at Tring over four decades provided an unusually high standard in those fields of zoological research in which Rothschild was particularly interested.

Rothschild was involved in many other activities during his lifetime in addition to "My Museum," as he termed it. He served for several years as a Member of Parliament, and was involved in some of the early negotiations which would ultimately result in the creation of the State of Israel. On a sadder note, for forty years he permitted himself to be blackmailed by a charming, witty, aristocratic, but ruthless peeress who at one time had been his mistress. Aided and abetted by her husband, she ruined him financially, destroyed his peace of mind for four decades, and eventually forced him to sell his invaluable collection of birds. Rothschild evidently permitted himself to be placed in this position until after the death of his formidable mother early in 1935 because he feared her reaction if the old relationship were made public. It was only after his mother's passing that he realized he could ignore his tormentors. By this time, however, the great majority of his marvellous bird specimens, numbering nearly a quarter of a million, had been sold for little more than a dollar apiece to the American Museum of Natural History in New York, bringing that institution's collection to a position of international primacy.

The author, herself a distinguished entomologist and niece of Lord Walter's, does not hide her uncle's often bizarre behavior. Mail which he did not wish to read, for example, was often tossed into convenient laundry baskets, and on one occasion, his younger brother Charles was compelled to bring four clerks to Tring who spent a week sorting out a two year accumulation. Although Lord Walter, in common

with his father and many other Rothschilds, ordered the destruction of many of his personal papers when he died, most of those sent to him by the blackmailing peeress were left to be discovered by his shocked sister-in-law after he was gone.

Walter Rothschild was not alone in making contributions to the natural sciences. His brother Charles was an able entomologist whose untimely death at the age of 46 virtually brought progress in nature conservation in the United Kingdom to a halt for a quarter of a century. With his passing in 1923, Walter was dependent upon his mother, then nearly 80, who with a staff of 14 ran the household, while Charles' sad but energetic widow, Rozsika, had charge of the farms and gardens at Tring. This meant that Rozsika handled the finances for Walter's museum. Fortunately, she was generally supportive of his work, though she had no particular understanding of it. When asked on one occasion to sum up his accomplishments in zoology, she simply described him as a splitter. At his death, his remaining collections passed to the British Museum.

Doctor Rothschild's book is not only an ably written account of her uncle's career, but of the curators, collectors and other personalities who were associated with him in the work of his museum and other enterprises. It is also recommended as an enjoyable reading experience.

KEIR B. STERLING

U.S. Army Ordnance Center and School, Aberdeen Proving Ground, Maryland 21005

The Trumpeter: Voices from the Canadian Ecophilosophy Network

Edited by Alan R. Drengson. Published by LightStar, 1138 Richardson Street, Victoria, B.C. V8V 3C8. 1985 membership $5.00, complete set of past newsletters $5.50 postpaid. Published quarterly.

This delightful and holistically ecological newsletter combines carefully thought-out ecological philosophy, poetry and illustrations in a very readable and enlightening style. The last issue contained 24 pages with slightly reduced double-columned, easy-to-read typed script (letter quality, microcomputer output?).

Newsletter goals stated in the second issue included forming "a network of persons who feel that preserving the integrity of the Earth's ecosystems requires reflections on ends, values and priorities. Environmental philosophy includes both theoretic and normative areas related to environmental policy. People in all disciplines contribute to environmental philosophy. When environmental philosophy is pursued as a practical activity which aims to understand and attune self and community to nature it becomes ecophilosophy." The writing is not dry!

A sampling of topics dealt with will give a more concrete idea of its contents: Towards a revisioning of reality; Plant symbiosis: a deeper ecology; Toward a sustainable agriculture; Ecopoetry, including Zenhaiku of Basho; Seeds of disaster (about commercialization of the farm seed industry and reduction in genetic diversity); Film and book reviews. The articles are a richly woven blend of knowledge and a pleasure to read.

After reading samples of issues lent by a neighbour I sent for a subscription and for the back issues. And I plan to give subscriptions for presents. I warmly suggest that you try a trial subscription. The blowing dandelion seed theme page and article end decos by Jenus Anderson Friesen and others by the editor are a delight.

DON E. MCALLISTER

Ichthyology Section, National Museum of Natural Sciences, Ottawa, Ontario K1A 0M8

How to Edit a Scientific Journal

By Claude T. Bishop. 1984. ISI Press, Philadelphia, Pennsylvania. xii + 138 pp., illus. U.S. $14.95.

Pick up this book and flip to page 44. Here is the classic editorial cartoon of all time, reproduced from the *American Scientist* (1978). It depicts a blackboard covered with awesome formulae through which a lab-coated academic is completing an "X" while his startled colleague questions: "That's *it*? That's peer review?"

This epic, and others as aptly chosen, is embedded in a text divided into nine chapters: The Literature of Science, Editors, Editorial Boards, The Review Process, Referees, Ethics, Keeping Track, Copy

Processing and Printing, and Post-Printing Activities. At the end there is a 27-entry Reference section and a four-page Index.

Claude T. Bishop bears impressive credentials to undertake a unique manual on scientific editing which emphasizes standards, procedures, and perspective above the mechanics of grammar and copy-marking. He has over eighty published contributions on carbohydrate chemistry and immunology of polysaccharides. He was immersed in the editorial process for over 17 years, first as a journal editor, then as editor-in-chief of 12 journals published through the National Research Council of Canada. But more than all these, he has a sense of humour — and the aptitude to use it to drive his points home.

Bishop emphasizes the axiom that editors of scientific journals should be active scientists, established in their careers but not so pressured that they will resent the time to edit. As such, most will be plunged into editing without formal training or experience. He largely dismisses such areas as routine flow of entry and acknowledgments, copy-editing, and proof-reading as being beyond the time an active scientist has to spare, and best turned over to the more competent and experienced hands of the assistants that any journal should provide. He does, however, provide instructions on the basic organization of these tasks, with examples, because it is the editor's responsibility to see that these tasks are dispatched with speed. Freedom from the mechanics of editing allows the scientific editor to focus on what he should do best: choosing referees, interpreting their comments to the authors, checking revisions and redirecting them to reviewers for further comment when necessary, and making the final reject/accept decisions which shape the journal itself. He dwells particularly on the editor-author-reviewer relationship and the spectrum of situations that can arise, with insights on the philosophical and practical problems that they pose, on the value of peer review, and on the question of who are the best choices for editors and reviewers.

A caution, however, is pertinent. Bishop's "idealized" editor tends to strongly reflect his own background in large well-subsidized journals. Not all of us can embrace all parts of his model organization for fear of bankrupting the publication we value, and yet the latter may make a contribution to science despite this. And some other portions of advice may not suit individual editorial taste — particularly, I could not embrace the circulation of comments of other reviewers to referees of a paper as a common operating procedure, although in some individual cases it does have value.

This book is a must for anyone contemplating editing a scientific publication — and Bishop points out that any productive scientist may expect to be asked to share the responsibility of making the system work by serving at least a short stint as an editor or associate editor. It should also be read by reviewers and authors of scientific contributions to give them a better perspective of how the process vital to the communication of scientific ideas actually works. Even those merely curious about the flow of science will find the text's incisive humour makes reading it a pleasant as well as highly informative exercise. Above all, it outlines standards to which every scientific editor can, at least, aspire.

FRANCIS R. COOK

National Museum of Natural Sciences, Ottawa, Ontario K1A 0M8

Wild Seasons Daybook: Aleta Karstad's Canadian Sketches

By Aleta Karstad. 1985. Methuen, Toronto. Unpaginated, illus. $12.95.

This is a delightful field diary for naturalists. For those of us who often procrastinate writing down our observations, the diary is already annotated with some thirteen years of experiences from the journal entries of Canadian nature artist Aleta Karstad. These entries illustrate her field experiences across Canada, as well as some excursions into the neighbouring states. Abundant paintings and sketches, illustrating seasonally and geographically representative flora, fauna, and landscapes tastefully decorate the book. These are supplemented by interesting annecdotes and scientific notes which are both seasonally appropriate and intriguing to the field naturalist. At the same time, ample space is provided to add one's own notes on personal wild seasons events and observations.

The talented paintings and sketches are, of course, what make this diary both unique and desirable. From sketches of simple romano beans or cedar seeds to intricate paintings of ecological interactions or scenic Canadian landscapes, from the stark realism of a great horned owl roadkilled on the way to Tobermory to beautiful perspectives of showy or yellow ladyslippers displayed from many perspectives, each page is amply illustrated. The sketches and notes provide an inducement to add one's own. The ideal would be to

fill the remaining spaces with several years of your own from observations of the wild seasons around you, thus providing a lasting history of nature and its interactions with your own passage through time.

The diary's format, while slightly large to fit in most pockets, is an ideal size for a small field daypack, large purse, or briefcase. The sturdy cover, heavy pages, and careful binding will stand up to many years of use. A three page appendix documents the dates and locations of the many illustrations. In my view, this is a valuable naturalist's field diary, which I intend to fill with my own notes over the next few years.

WILSON EEDY

R.R.#1, Moffat, Ontario L0P 1J0

NEW TITLES

Zoology

Advances in insect physiology, volume 18. 1985. Edited by M. J. Berridge, J. E. Treherne, and V. B. Wigglesworth. Academic Press, Orlando, Florida. 464 pp. U.S. $79.50.

American insects: a handbook of the insects of North America. 1985. By Ross H. Arnett, Jr. Van Nostrand Reinhold, New York. xiv + 850 pp., illus. U.S. $79.50.

Aquatic Oligochaeta. 1984. Edited by G. Bonomi and C. Erseus. Junk (U.S. distributor Kluwer, Boston). From a symposium, Pallanza, Italy, September 1982. Reprinted from Hydrobiologia, volume 115. xiv + 240 pp., illus. U.S. $68.50.

†**Arizona wetlands and waterfowl.** 1985. By Davic E. Brown. University of Arizona Press, Tucson. xi + 169 pp., illus. U.S. $24.95.

The atlas of Australian birds. 1984. By M. Blakers, S. J., J. F. Davies, and P. N. Reilly. Melbourne University Press (U.S. distributor International Specialized Book Services, Beaverton, Oregon). x1vi + 738 pp. U.S. $60.

Atlas of invertebrate macrofossils. 1985. Edited by John W. Murray. Halsted (Wiley), New York. xiv + 241 pp. U.S. $24.95.

The Audubon wildlife report, 1985. 1985. By the National Audubon Society, New York. 650 pp. U.S. $16.50.

Avian biology, volume 8. 1985. Edited by Donald S. Farner, James R. King, and Kenneth C. Parkes. Academic Press, Orlando, Florida. xxiv + 256 pp., illus. U.S. $49.50.

Bats: a natural history. 1984. By John E. Hill and James D. Smith. University of Texas Press, Austin. 243 pp., illus. U.S. $24.95.

The behavior of penguins: adapted to ice and tropics. 1984. By Dietland Muller-Schwarze. State University of New York Press, Albany. xii + 193 pp., illus. Cloth U.S. $29.50; paper U.S. $10.95.

†**The biology of Australian frogs and reptiles.** 1985. By G. Grigg, R. Shine, and H. Ehmann. Surrey Beatty and Sons, Chipping Norton, Australia. xvi + 527 pp., illus. U.S. $59 (includes postage).

The biology of terrestrial isopods. 1984. Edited by S. L. Sutton and D. M. Holdich. Symposium of the Zoological Society of London, No. 53. xxvi + 518 pp., illus. U.S. $53.

*__Biology of the arctic charr.__ 1985. Edited by Lionel Johnson and Bonnie Burns. University of Manitoba Press, Winnipeg. 584 pp., illus. $60.

Birds of North America: eastern region: a quick identification guide to common birds. 1985. By John Bull, et al. Collier (Macmillan), New York. 157 pp., illus. Cloth U.S. $16.95; paper U.S. $9.95.

*__Birds of Ontario.__ 1985. By J. Murray Speirs. Natural Heritage/Natural History, Toronto. 2 volumes. xiv + 538 pp., illus. and xiv + 986 pp., illus. $49.95 and $24.95.

The colonization of land: origins and adaptations of terrestrial animals. 1984. By Colin Little. Cambridge University Press, New York. viii + 290 pp., illus. U.S. $99.50.

Corals and coral reefs of the Galapagos Islands. 1984. By Peter W. Glynn and Gerald M. Wellington. University of California Press, Berkeley. xvi + 330 pp., illus. U.S. $45.

Coral reefs. 1984. By Sylvia A. Johnson. Lerner, Minneapolis. 54 pp., illus. U.S. $8.95.

Crabs of the Chinese seas. 1986. By A. Dai. Springer-Verlag, New York. 600 pp., illus. U.S. $94.50.

Evolutionary ecology of marsupials. 1985. By Anthony K. Lee and Andrew Cockburn. Cambridge University Press, New York. viii + 274 pp., illus. U.S. $54.50.

†**L'exploitation commerciale des poissons-appâts (mené) dans la Région de Montréal.** 1985. Par Jean-René Mongeau. Rapport Technique N. 06-37. Québec Ministère du Loisir, de la Chasse, et de la Pêche, Montréal. xiii + 144 pp., illus.

†**Honeybee ecology: a study of adaptation in social life.** 1985. By Thomas D. Seeley. Princeton University Press, Princeton. x + 201 pp., illus. Cloth U.S. $39.50; paper U.S. $10.50.

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TABLE OF CONTENTS *(concluded)*

Mailing date of the previous issue (volume 100, number 2): 3 October 1986

THE CANADIAN FIELD-NATURALIST Volume 100, Number 3 1986

Articles

Notes

concluded on inside back cover

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Cover: Female Osprey, *Pandion haliaetus*, with young chick photographed at Cole Harbour, Nova Scotia, July 1981 by Erick Greene. *See* article by Greene and Freedman pp. 470–473.

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Responses of Spotted Salamander, *Ambystoma maculatum*, Populations in Central Ontario to Habitat Acidity

Karen L. Clark

Biota Environmental Contractors, Box 21, Dorset, Ontario P0A 1E0

Clark, Karen L. 1986. Responses of Spotted Salamander, *Ambystoma maculatum*, populations in central Ontario to habitat acidity. Canadian Field-Naturalist 100(4): 463–469.

Reproductive success of the Spotted Salamander, *Ambystoma maculatum*, was monitored in twenty ephemeral ponds in central Ontario that had varying pH, alkalinity, and calcium concentrations. Mean pH of the ponds ranged from 4.55 to 6.37 and alkalinity from -0.4 to 12.2 mg/L $CaCO_3$ (calcium carbonate). Hatching success ranged from 0 to 99%. Stepwise multiple linear regression analysis selected alkalinity and pond area as predictors of the total number of egg masses/pond and the total number of eggs hatched/pond. The best predictor of hatching success was pH. Hatching success was 80% in a pond at pH 4.51. This was significantly lower than the 88% hatching success observed in a pond at pH 6.15. Larvae exposed in a pond at pH 4.97 had greater survival (64%) in enclosures where $CaCo_3$ was added and the pH elevated to 5.30 than in enclosures without $CaCO_3$ additions (46% survival). Eggs collected from one pond at pH 4.51 and another pond at pH 6.21 had similar hatching success when exposed at pH 4.51. This suggests that the egg stage of both populations of salamanders was equally tolerant of acidity. Survival of larvae collected as eggs from a pond with pH 4.51 was greater (62%) than larvae collected as eggs from a pond with pH 6.15 (46%) when both were exposed to pH 4.51. These results imply that larvae from the population breeding in the acidic pond were more tolerant of increased acidity than those from the population breeding in the less acidic pond.

Key Words: *Ambystoma maculatum*, Spotted Salamander, eggs, larval survival, pH, hatching success, Ontario.

Acidic deposition has led to the acidification of aquatic habitats in Scandinavia (Almer et al. 1974) and North America (Dillon et al. 1978). The extent of acidification of lakes and streams and the effects on such organisms as fish, phytoplankton and zooplankton have been well documented (reviewed by Harvey et al. 1981; Haines 1981). Small ponds, however, are important breeding habitats for many amphibian species but have received less attention. Hydrogen ion toxicity to amphibian eggs has been documented for a number of species in the United States (Gosner and Black 1957; Pough 1976; Saber and Dunson 1978). One salamander species that is particularly sensitive to strong acid is the Spotted Salamander, *Ambystoma maculatum*. The pH for maximum hatching success is between 7 and 9 (Gosner and Black 1957; Pough 1976; Pough and Wilson 1977). The eggs of this species are deposited in the spring in temporary ponds that may consist of very acidic water derived from snowmelt and spring rains. In a survey of 17 breeding ponds in New York, Pough (1976) found that 14 had pH < 6.0. At pH < 7.0 eggs may show increased mortality and developmental deformities such as curvature of the spine and stunted gills may occur (Pough 1976; Pough and Wilson 1977). The larval stage of *A. maculatum* is also aquatic but its sensitivity to low pH is not known.

Since habitat acidification can affect survival of eggs of *A. maculatum* (Pough 1976) and may potentially reduce larval survival as well (Saber and Dunson 1978), selection against intolerance to acidity during either the egg or larval stages could occur. For example, Pough (1976) observed considerable variability in hatching success between clutches of eggs within the same acidic ponds. Fidelity of *A. maculatum* to breeding ponds is pronounced and recruitment from adjacent populations is slight (Husting 1965; Shoop 1965, 1968). Large increases in egg mortality due to acidification may result in strong selection pressure against acid-intolerant individuals. In Massachusetts, where ponds are naturally acidic due to the bedrock and soil, *A. maculatum* populations are tolerant to pH values as low as 4.2 (Cooke 1983). In New York, however, Tome and Pough (1982) did not find any difference in tolerance to acidity of *A. maculatum* eggs collected from a pond

with a pH of 4.0 compared to those collected from a pond with a pH of 7.0.

Tolerance to acidity could also occur as a result of acclimation in earlier life history stages. Previous acclimation to acidity may increase tolerance to depressions in pH during storms.

In central Ontario, an area presently receiving substantial deposition of strong acids (Dillon et al. 1978), *A. maculatum* is the most common salamander that breeds in meltwater ponds (Clark and Euler 1982). This study investigated the influence of acidity on egg hatching success and larval survival of *A. maculatum*, and determined whether eggs and larvae from an acidic pond were more tolerant to acidity than those from a less acidic pond.

Methods

Pond Census — Reproductive Success of Natural Populations

In the spring of 1980, 20 meltwater ponds in Muskoka (44°10′N, 78°30′W) and Haliburton (45°05′N, 79°03′W) counties in Ontario were searched weekly for *A. maculatum* egg masses from mid-April until all eggs had hatched in mid-July. The ponds were in undisturbed woodlands, clearings and roadside ditches. The two criteria used in selecting the ponds were that the depth was adequate for egg deposition (> 0.25 m) and that there were no fish in the ponds, since fish are a major amphibian predator. Table 1 describes the physical and chemical characteristics of the ponds.

When an egg mass was first located, the number of live and dead eggs was counted. Numbers of egg masses were counted weekly, but egg numbers were not recounted until hatching. The total number of egg masses/pond, total number of eggs hatched/pond, and the percentage of eggs which hatched in each pond were recorded using methods described by Cooke (1983).

The pH, calcium (Ca) concentration and alkalinity were determined weekly using methods presented by the Ontario Ministry of the Environment (1975). In larger ponds an average pH was calculated from pH measurements at several locations in each pond. The pH was converted to H+ concentration to compute means.

Stepwise multiple linear regression analyses were used to select the water chemistry variables most important in predicting reproductive success. Pond surface area was included because several attributes of pond size (e.g. diurnal fluctuations in water temperature, risk of desiccation) may affect population size. Ponds with no egg masses were included in the analysis to determine whether pH was a factor in ponds not supporting a population of breeding salamanders. *Ambystoma laterale* (Blue-

TABLE 1. Area and mean (range in parentheses) chemical concentrations[a] in 20 ponds during *A. maculatum* egg development and the number of egg masses, total number of eggs, and % hatching success in each pond.

Area (m^2)	pH	Alkalinity (mg/L $CaCO_3$)	Ca (mg/L)	No. of masses	No. of eggs	% hatch
27	4.55 (4.45–4.68)	0.4 (-0.4–1.0)	—	1	40	0
8	4.99 (4.85–5.35)	1.4 (-0.2–2.0)	2.5 (2.0–3.0)	3	92	29
322	5.06 (4.80–5.20)	1.8 (-0.4–2.2)	4.7 (4.0–6.0)	25	613	0
73	5.08 (4.90–5.29)	1.6 (0.07–3.2)	3.0 (2.7–3.4)	0	0	—
3	5.32 (5.25–5.38)	2.4 (1.9–2.6)	3.4 (3.0–3.8)	0	0	—
26	5.50 (5.05–6.05)	6.1 (3.7–8.9)	3.3 (2.2–4.2)	7	225	84
36	5.53 (5.35–5.73)	3.2 (2.8–3.5)	3.2 (2.2–4.2)	3	66	98
519	5.58 (5.35–5.75)	3.7 (5.3–7.1)	2.6 (1.4–3.6)	0	0	—
48	5.65 (5.55–5.88)	4.5 (2.7–6.3)	3.3 (2.8–3.8)	11	285	0
3	5.65 (5.50–5.70)	2.0 (1.9–2.2)	4.7 (4.0–5.8)	6	121	0
45	5.74 (5.55–5.59)	6.7 (6.7–8.1)	2.6 (2.0–2.9)	8	275	99
753	5.80 (4.95–6.10)	4.5 (2.8–5.1)	1.7 (0.6–2.7)	66	3330	85
43	5.84 (5.60–6.30)	9.9 (5.1–18.0)	2.8 (2.8)	22	760	46
101	5.90 (5.85–6.39)	7.7 (4.6–9.0)	4.3 (4.1–4.4)	5	103	81
52	5.95 (5.75–6.14)	5.7 (5.2–6.8)	1.9 (1.2–2.2)	11	251	66
75	6.02 (5.94–6.10)	7.9 (6.0–11.7)	3.3 (2.0–4.0)	33	907	87
71	6.03 (5.52–6.50)	5.1 (2.8–6.9)	3.1 (2.4–3.7)	27	1260	70
107	6.10 (5.03–6.34)	9.2 (3.0–10.0)	3.6 (3.4–4.2)	5	140	47
103	6.15 (5.85–6.28)	12.2 (9.2–17.2)	4.0 (2.2–5.3)	112	3096	66
22	6.37 (5.05–6.40)	17.7 (5.5–10.4)	3.0 (2.0–3.0)	0	0	—

[a]n = 5-7/pond

spotted Salamander) egg masses occasionally occurred in the ponds but no more than 3 were ever present and these are not included in the analyses. In the stepwise multiple linear regression analysis with hatching success and the number of eggs hatched/pond, ponds with no egg masses were not included because hatching success or the number of hatched eggs could not be computed for those ponds.

Egg Transfers — Acid Tolerance of the Egg Stage

In 1981 an experiment was carried out to compare the tolerance to acidity of *Ambystoma maculatum* from two ponds with differing acidity. Four ponds, two for collections and two for exposures, were used in this experiment but none of the ponds had been enumerated in the 1980 pond census. Twenty egg masses were collected from a pond with pH 4.51 (Pond C1) and 20 from a pond with pH 5.87 (Pond C2). All eggs were 1-3 days old and in stages 10 to 13 (Rugh 1962). Each egg mass was divided into sections with 10-40 eggs/section. One section of each egg mass was exposed in a pond with pH < 5.0 (Pond E1) and in a pond with pH > 6.0 (Pond E2). On the same day, twenty 750 mL plastic containers with 505 micron fiberglass screening on each end with two sections of egg mass/container were placed in Ponds E1 and E2. Ten of the containers at each exposure pond had eggs from pond C1 and ten containers had eggs from pond C2. Areas of E1 and E2 that were similar to the natural breeding habitat were used as the exposure sites. Ponds E1 and E2 were approximately 30 m^2 and the sites were 1 m deep with little tree cover and no aquatic vascular plants. Hatching success was monitored and hatched larvae were inspected for curvature of the spine or any other deformities.

Water samples were analyzed weekly for pH and alkalinity and biweekly for calcium, dissolved organic carbon (DOC), dissolved oxygen and total aluminum (Al). DOC and Al were measured because it has been suggested that these also might influence survival in acidic pond waters (Birge 1978; Saber and Dunson 1979; Clark and Hall 1985).

Larval Exposures — Acid Tolerance of the Larval Stage

To determine whether two populations had differing tolerance to acidity during the larval stage, 100 C1 and 100 C2, 5-day old larvae (stage 40, Rugh 1962) that had hatched in pond E1 (pH 4.51) were placed in enclosures (with 50 larvae/enclosure) in pond E1. Some selective mortality of acid tolerant embryos may have occurred among the eggs oviposited in the more acidic pond (C1). However, both C1 and C2 larvae were exposed in E1 during the egg stage and mortality due to acid stress occurs mainly at hatching (Dunson and Connell 1982; Clark and Hall 1985) and so the differences in larval survival should be mainly a result of population differences in acid tolerance and not because acid tolerant individuals from the acidic pond were used in the experiment. The enclosures (0.33 m^3) were constructed of PVC pipe over which fiberglass screening was stretched. Predators were excluded from the enclosures. The density was low (50 larvae/0.33 m^2), food was abundant, and no evidence of cannibalism was ever observed.

To determine whether elevating the pH could result in greater larval survival, 100 C2 larvae that had developed until hatching in E2 were placed in the outlet of E1 in two enclosures [described in the preceding paragraph] (50 larvae/enclosure) where 750 ml of fertilizer grade $CaCO_3$ (calcium carbonate) had been added. Survival of these larvae was compared to that of 100 C2 larvae exposed in E1 with no $CaCO_3$ present. Flow rates through the enclosures were low enough that pH was always elevated in the enclosure. The number of surviving larvae was counted on July 14 before any larvae had transformed into adults. To ensure that all larvae were subjected to similar handling stress, they were transported to the laboratory and then back to the ponds before exposure.

Water chemistry in the pond and within the $CaCO_3$ treated enclosures was determined in a similar manner as for the egg exposures.

Results

Reproductive Success of Natural Populations

The pH in the 20 ponds that were enumerated for salamander eggs ranged from 4.55 to 6.37 and alkalinity from -0.4 to 12.2 mg/L $CaCO_3$. Only 5 of the 20 ponds had a mean pH > 6.0 (Table 1). Temperature fluctuated between 8 and 15°C. Dissolved oxygen always exceeded 6 mg/L in the ponds.

A. maculatum eggs were found in 16 of the 20 ponds. Mean hatching success was 55% which is within the range reported in New York (45-60% at pH 4.5-6.0), an area also affected by acidic deposition (Pough 1976). The number of egg masses/pond was positively correlated with alkalinity and pond area (Table 2) and both of these variables were selected in the stepwise multiple linear regression analysis (number of egg masses/pond = $(0.06 \times$ pond area$) + (0.42 \times$ alkalinity$) - 13.0$; $R^2 = 0.36$; $F = 4.87$; df = 2,17; $p < 0.05$). The number of eggs hatched/pond was positively correlated with pond area (Table 2). In the stepwise multiple linear regression analysis,

TABLE 2. Product moment correlation coefficients for number of egg masses/pond, total number of eggs hatched/pond and % hatching success with selected water chemistry variables and pond area.

	No. of masses (n = 20)	No. of eggs hatched (n = 15)	% hatch (n = 15)
pH	0.34	0.37	0.53*
Ca	0.04	-0.39	-0.52*
Alkalinity	0.45*	0.32	0.47
Pond area	0.40*	0.71*	0.11

*$p < 0.05$

however, pond area and alkalinity were selected (number of eggs hatched/pond = (3.4 × pond area) + (1.07 × alkalinity) — 511; $R^2 = 0.68$; $F = 12.5$; df = 2,12; $p < 0.05$). Percent hatching success was correlated with pH and Ca concentration (Table 2). In the stepwise multiple linear regression only pH was selected (hatching success = (37.9 × pH) — 158.5; $R^2 = 0.28$; $F = 5.1$; df = 1,15).

Egg Transfers — Acid Tolerance of the Egg Stage

During the egg exposures the mean pH of ponds E1 and E2 was 4.51 and 6.15, respectively (Table 3). E1 pond had higher DOC and Al concentrations than E2 pond. Ponds E1 and E2 were at the extremes of pH of the ponds enumerated in 1980 (Table 1) and so hatching success should have been similar to that measured in the 1980 ponds. In E1 and E2 hatching success was much higher (> 75%, Table 4) in E1 pond than in any of the ponds monitored in 1980 ($\bar{x}$ = 62%) even though all of the ponds had pH > 4.51 (Table 1). Part of the difference in hatching success between years was that in the egg transfer experiments in 1981, infertile eggs or eggs that died prior to collection were removed and not used in the experiment. If the 21-26% mortality which occurred prior to egg collection is included in the 1981 measures of hatching success in the egg transfer exposures, then hatching success is comparable between years.

In the egg transfer experiment in 1981, hatching success of eggs from C1 and C2 was not significantly different when they were incubated at pH 4.51 (pond E1) (Table 4); this indicates that eggs from these two populations were equally tolerant to acidity.

Hatching success of C1 and C2 eggs was reduced at pH 4.51 (pond E1) compared to those incubated at pH 6.15 (pond E2) (Table 4), indicating that reduced pH was related to a decline in hatching success regardless of egg source. There was evidence that pH was causing a physiological stress since eight percent of the embryos (from both C1 and C2) that hatched in pond E1 (pH 4.51) had curved spines whereas no larvae in pond E2 (pH 6.15) had curved spines. The degree of curvature varied greatly with severe cases only being able to rest on their sides and swim in tight 2-3 cm circles.

Acid Tolerance of the Larval Stage

C1 larvae exhibited significantly greater survival (62%) than C2 larvae (46%) when exposed in pond E2 ($\chi^2 = 5.15$, $p = 0.03$, computed using the number of live and dead larvae).

During the larval exposures the mean pH in pond E1 was 4.97 (Table 5). Addition of $CaCO_3$ to the enclosures elevated the pH to 5.30 and increased alkalinity from 0.91 mg/L $CaCO_3$ to 3.74 mg/L $CaCO_3$ (Table 5). Although the chemistry varied during the larval exposures, pH and alkalinity were always higher in the limed enclosures than in the pond water. Survival of C2 larvae was significantly greater with $CaCO_3$ (64%) than without $CaCO_3$ (46%) ($\chi^2 = 6.55$, $p < 0.05$).

Discussion

Hydrogen Ion Toxicity to the Egg and Larval Stages

The pH of all ponds enumerated for *A. maculatum* eggs was below the optimum (pH 7.0-9.0) for egg development (Pough 1976). The acidic condition of the majority of the ponds is likely representative of many *A. maculatum* breeding habitats in central Ontario. The occurrence of fewer egg masses and the production of fewer larvae in small low-alkalinity

TABLE 3. Mean (range)[a] chemical concentrations in ponds E1 and E2 during the egg exposures (30 April – 1 June).

	Pond E1	Pond E2
pH	4.51 (4.33– 4.94)	6.15 (6.09–6.22)
Alkalinity (mg/L $CaCO_3$)	-1.63 (-2.40– 0.06)	6.19 (3.03–7.88)
DOC (mg/L C)	8.4 (1.8 – 12.1)	2.9 (2.7 –3.1)
Ca (mg/L)	2.0 (2.0 – 2.2)	3.8 (3.4 –4.2)
Total Al (mg/L)	0.16	0.07

[a]n = 6 for pH, alkalinity
n = 3 for DOC and Ca
n = 1 for Al

TABLE 4. Mean percent hatching success (with the range in parentheses) of eggs collected from ponds C1 and C2 exposed from the neurula stage until hatching in ponds E1 and E2 (n = 5–9 per exposure).

	Collection Ponds	
Exposure Ponds	C1 (pH 4.51)	C2 pH 5.87)
E1 (pH 4.51)	80[a] (67-91)	74[b] (47-92)
E2 (pH 6.15)	88[a] (80-90)	84[b] (71-100)

[a]Means are significantly different at $p < 0.05$ Mann-Whitney U test
[b]Means are significantly different at $p = 0.07$ Mann-Whitney U test

ponds suggest that such ponds represent poor breeding habitat. Low alkalinity alone cannot be toxic but reduced pH is usually associated with low alkalinity and excess hydrogen ions are toxic. Alkalinity was more important than pH in predicting the number of egg masses/ pond and the number of eggs hatched/pond, likely because alkalinity is less variable than pH and is an indicator of a pond's sensitivity to pH depressions.

The best predictor of hatching success was pH. Hatching success could have been directly influenced by the elevated hydrogen ion concentration (Gosner and Black 1957; Pough 1976). The reduced hatching success in the more acidic ponds may have been the result of shrinkage of the perivitteline membrane and inhibition of hatching (Gosner and Black 1957; Pough 1976; Pough and Wilson 1977; Dunson and Connell 1982), or increased susceptibility to fungal infection (Strijbosch 1979; Clark and LaZerte 1985).

Reduced hatching success in ponds with increased acidity was also observed in the egg transfer experiment. Although the causes of egg mortality were not determined, physiological stresses must have been affecting the eggs because developmental deformities occurred only in embryos exposed at pH 4.51. The difference in hatching success in the ponds at pH 4.51 and 6.12 was small (≤ 10%) and this alone may not explain why, in the pond census, fewer salamanders were breeding in acidic ponds. Since *A. maculatum* show pronounced fidelity to natal breeding ponds (Husting 1965; Shoop 1965, 1968), immigration into acidic ponds would be low, and so reduced hatching success in conjunction with increased larval mortality and other potential stresses due to habitat acidity (eg. changes in habitat structure and food resources) may all combine to reduce the sizes of populations of salamanders breeding in acidic ponds.

The larval stage was also negatively affected by acidity. Hydrogen ion toxicity to the larval as well as the egg stage would reduce recruitment even further for salamander populations breeding in acidic ponds.

Acid Tolerance of the Egg and Larval Stages

The results of the egg transfers were similar to those of Tome and Pough (1982) who found no evidence of tolerance to acidity. The only other amphibian species that has been tested is *Rana sylvatica* (Wood Frog), and Pierce and Sikland (1985) found wide variation in acid tolerance among embryos.

There were differences in acid tolerance among larvae since survival of C1 larvae was greater than C2 larvae when exposed to pH 4.97. Similar results have been reported for *R. sylvatica* larvae (Pierce 1985). *R. sylvatica* larvae from acidic ponds can tolerate reduced pH levels better than larvae from neutral ponds (Pierce 1985). Tolerance to acidity could occur by selection for salamanders that are less sensitive to low pH. Alternately, acclimation in the very early life stages could increase tolerance to acidity.

Other Potential Sources of Toxicity

Other chemical variables associated with low pH which were potentially toxic in the test waters were DOC and Al. Dissolved organics can be toxic to amphibian eggs, although the actual toxic agent has not been identified (Gosner and Black 1957; Beebee and Griffin 1977; Saber and Dunson 1978). Polyphenolics are one group of compounds included in dissolved organics that may be toxic (Shapiro 1967;

TABLE 5. Mean (range)[a] chemical concentrations in E1 pond in the enclosures with and without $CaCo_3$ additions during the larval exposures (2 June – 14 July).

	Pond E1	Pond E2
pH	4.97 (4.38– 5.57)	5.30 (4.61– 5.95)
Alkalinity (mg/L $CaCO_3$)	0.09 (-2.35– 6.06)	3.74 (-1.18– 8.82)
DOC (mg/L C)	14.6 (2.0 –23.0)	14.0 (2.0 –21.0)
Ca (mg/L)	2.5 (2.2 – 2.8)	3.0 (2.4 – 4.2)

[a]n= 6 for pH and alkalinity
n= 3 for DOC and Ca

Gjessing 1970; Saber and Dunson 1978). Since the concentration of dissolved organic compounds was much higher in pond E1 water than in pond E2 water, it cannot be ruled out as contributing to the reduced hatching success in pond E1.

The total Al concentrations in pond E1 exceeded the 10-20 μ g/L Al at pH < 4.75 reported by Clark and LaZerte (1985) to reduce *Bufo americanus* (American Toad) and *R. sylvatica* hatching success. Al, however, forms complexes with dissolved organic ligands. When combined with organics, Al is less toxic to fish (Driscoll et al. 1980; Baker and Schofield 1982) and may be less toxic to amphibians. Since inorganic Al and organically bound Al were not measured it is not possible to determine whether there was sufficient inorganic Al to produce a toxic effect in the exposure ponds.

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Status of the Osprey, *Pandion haliaetus*, in Halifax and Lunenburg Counties, Nova Scotia

ERICK GREENE[1] and BILL FREEDMAN

Department of Biology, Dalhousie University, Halifax, Nova Scotia B3H 4J1
[1]Present address: Department of Biology, Princeton University, Princeton, New Jersey 08544.

Greene, Erick, and Bill Freedman. 1986. Status of the Osprey, *Pandion haliaetus*, in Halifax and Lunenburg counties, Nova Scotia. Canadian Field-Naturalist 100(4): 470–473.

Intensive nest surveys along the Atlantic coast in Halifax and Lunenburg counties, Nova Scotia, located 153 Osprey (*Pandion haliaetus*) nests in 1981. A sample of 61 nests had an average productivity of 1.09 young fledged per occupied nest. Analysis of productivity and survivorship data suggests that this Osprey population is growing at a rate of ca. 5% per year.

Key Words: Osprey, *Pandion haliaetus*, population status, productivity, Nova Scotia.

Drastic population declines occurred among Ospreys (*Pandion haliaetus*) along the New England coast during the 1950s and 1960s (Henny and Wight 1969). These declines have been linked with eggshell thinning caused by contamination with chlorinated hydrocarbons (Hickey and Anderson 1968; Spitzer et al. 1977). With the reduction in the use of DDT and its eventual ban in the United States in 1972, Osprey populations have stabilized and then increased there (Spitzer and Poole 1980).

In Canada Ospreys also were considered endangered (Godfrey 1970), although it is unclear to what extent Osprey populations actually changed. In the Maritime Provinces prior to the 1960s, accounts of the population status of Ospreys had been rather anecdotal and subjective (for a review see Stocek and Pearce 1978); few nest locations were given and survey effort was poorly specified, so that meaningful comparisons between surveys are difficult to make. It is conceivable that Osprey populations in the Maritime Provinces may have remained stable during the crash that occurred in New England. Here we report the results of intensive population surveys which were conducted so that the future monitoring of this population can be made with confidence.

Study Area and Methods

The coastline of Nova Scotia in Halifax and Lunenburg counties is indented by numerous estuaries and bays. Spruce-fir forests predominate at lower elevations, and little tree harvesting occurs along the coast. A major urban/industrial centre (Halifax-Dartmouth; population ca. 275 000) is located along the coast in the middle of the study area (Figure 1).

As part of a larger study investigating the foraging ecology of Ospreys (Greene et al. 1984), the coastal areas between Lunenburg (Lunenburg County) and Jeddore Harbour (Halifax County) were systematically surveyed for Osprey nests throughout the spring and summer of 1981. Nests were located by extensive ground and boat searches, by aerial surveys from fixed-wing aircraft, and by enquiries of local residents and naturalists. The aerial surveys were conducted on 19 May, 12 and 19 June, and 23 July 1981 from a 2-seater Piper Cub flying at ca. 90 km/h at 40-60 m above ground level.

A sample of accessible nests for which we could assess occupancy was monitored to determine reproductive success. All terminology regarding nest status and productivity follows Postupalsky (1974), with the slight modifications of Prévost et al. (1978): an occupied nest is attended by two birds prior to egg laying; an active nest had eggs (seen, or inferred when a bird sitting on the nest did not flush during an egg survey); a productive nest had young raised to fledging age; productivity is the number of young fledged per occupied nest. (Note that there is confusion in the terminology used in the literature: some studies report raptor productivity as young fledged per *active* nest, and others report is as young fledged per *occupied* nest. Postupalsky (1977) has made a plea for a unified terminology, and has urged that productivity be reported as the latter. We have followed Postupalsky in Table 1.)

Results and Discussion

Population status

A total of 153 nests was located in the study area (Figure 1). Several areas within the study plot (McNabs and Lawlors islands, Cow Bay, Cole Harbour and Mahone Bay) were intensively surveyed, and many repeated visits failed to uncover new nests. We believe that in these areas our nest counts are virtually complete. To facilitate future comparisons with this study, more detailed 1:50 000 topographic

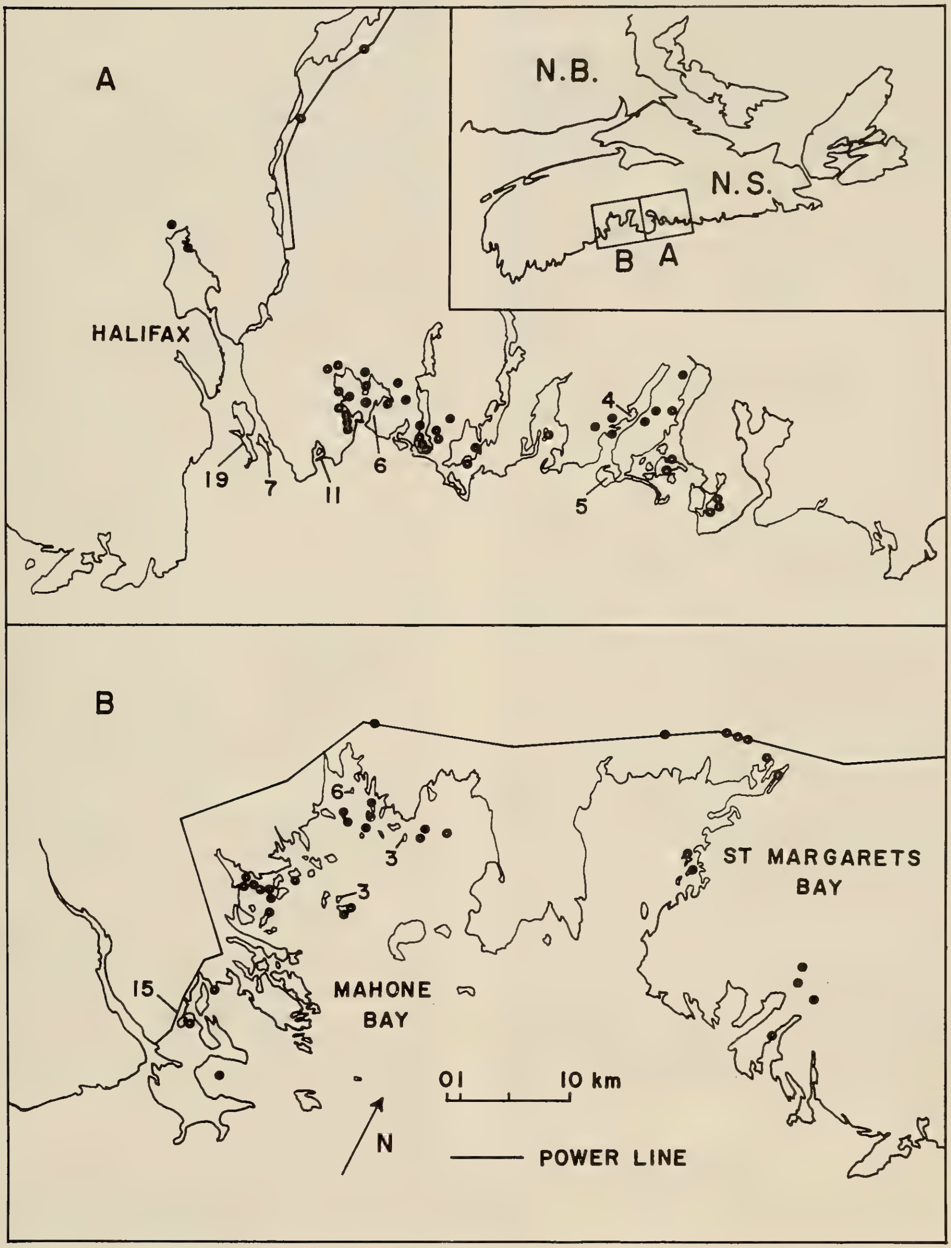

FIGURE 1. Osprey nests located in 1981 in Halifax and Lunenburg counties, Nova Scotia. Numerals indicate the numbers of Osprey nests in dense groupings.

maps showing exact nest locations and survey effort are available from the Depository of Unpublished Data (CISTI, National Research Council of Canada, Ottawa, Canada K1A 0S2).

Of the total nests found, 133 (87%) were occupied, 96 (63%) were active, 11 (7%) were unoccupied, and the status of 9 (6%) could not be determined. Twenty-two nests were built on power poles. Fifteen of those occurred along a 4 km segment of a power line near Lunenburg. The remaining 131 nests (86%) were built in natural sites. In other regions the proportion of natural nest sites was much lower (roughly one third of 138 active nests between New York City and Boston (Spitzer and Poole 1980); 4 of 26 nests in Antigonish County, Nova Scotia (Prévost et al. 1978). This lower proportion appears to be related to a loss of potential natural sites to forestry and urbanization. We attribute the relatively high percentage of natural nest sites in this study to the abundance of suitable nesting trees near the shore. The concentration of nests on power poles near Lunenburg appears to have developed after several nearby islands in Mahone Bay supporting nesting Ospreys were cleared of all dead trees (K. Gregoire, personal communication).

The coastline around Halifax presently supports a large Osprey population, which is comparable in density to that of the mid-Atlantic seaboard of the United States (Spitzer and Poole 1980) and to the Fennoscandian Osprey population (Östërloff 1977), one of the densest in the world. Worthy of special note is the concentration of nesting Ospreys on McNabs and Lawlors islands at the mouth of Halifax Harbour. Twenty-six nests (twenty-one occupied) occurred on those islands, in close proximity to a major urban and industrial centre.

In a valuable study of Osprey distributions in the Maritime Provinces conducted in 1974 and 1975, Stocek and Pearce (1978) identified "significant concentrations" of Ospreys in Halifax and Lunenburg counties. They located only 64 nests in a much larger area than the one covered by this study. In 1976 an Osprey nest survey was conducted in Halifax County by the Nova Scotia Department of Lands and Forests (P. J. Austin-Smith, personal communication). In the area common to that survey and the present survey, 53 nests were found in 1976 and 101 nests were found in 1981. Only 8 of the nests found in 1976 were not found again in 1981, and an additional 56 new nests were discovered.

Both of the previous studies covered larger areas than this study. Such coarse-grained surveys are invaluable in identifying geographic areas of high and low Osprey abundance. However, because a survey of a large geographic area usually sacrifices survey intensity, monitoring local population changes from such surveys will be difficult. It is unlikely that population growth alone is responsible for the apparent increase in the number of Osprey nests between those surveys and ours, as the observed productivity (see Reproductive Success and Productivity section) suggests that that Osprey population is growing now by about 5% annually. Differences in survey effort and aircraft speed and height may explain most of the differences.

Reproductive Success and Productivity

Sixty-one Osprey nests were found early enough in the breeding season to allow assessment of nesting status. The reproductive success and productivity for that subsample of nests are shown in Table 1.

Henny and Wight (1969) estimated that 0.95 to 1.30 young fledged per active nest were necessary to maintain a stable Osprey population. However, Spitzer (1980) noted that 0.79 young fledged per active nest was sufficient to stabilize a population of Ospreys between New York City and Boston. In this study we observed 1.50 young fledged per active nest, a figure higher than either Henny and Wight's (1969) or Spitzer's (1980) estimates of the minimum productivity required to maintain a stable population. Our productivity figure is somewhat less than others have reported for Maritimes Ospreys: Stocek and Pearce (1978) reported 1.49 young per occupied nest for all the Maritime Provinces; Prévost et al. (1978) reported 1.18 young per occupied nest in Antigonish County, Nova Scotia.

We have estimated the growth rate of this Osprey population using standard demographic techniques

TABLE 1. Reproductive success of Ospreys in Halifax and Lunenburg counties, Nova Scotia, in 1981[1].

Number of nests	Occupied nests	Active nests	Productive nests	Young raised to fledgling age	Productivity ($\bar{x}$ + s.d.)
61	44	32	24	48	1.09 ± 1.14

[1]Definition of terms follows Postupalsky (1974) with slight modifications of Prévost et al. (1978), and are listed in the text.

(e.g. Keyfitz 1977). We assumed that Nova Scotia Ospreys have the same survivorship and recruitment schedules as the New England population studied extensively by Spitzer (1980), i.e. 60% survivorship during the first year after fledging and 85% per year thereafter. As Ospreys (in New England) initiate breeding between 3 and 5 years of age, the proportion of a cohort breeding [50% in year 3, 80% in year 4, 100% thereafter: Spitzer (1980)] was multiplied by the productivity observed in our study. Those fecundity and survivorship data were incorporated into a 15x15 Leslie Matrix. The principal eigenvalue of that matrix (which represents the population's finite rate of increase) is $\lambda = 1.053$. This result suggests that that Osprey population is presently growing at about 5% per year.

That method of determining λ makes several assumptions. How sensitive is the eigenvalue λ to changes in those assumptions? We assumed that Ospreys did not live longer than 15 years (i.e. we used a 15×15 matrix), although an Osprey 25 years old has been reported (Spitzer 1980). However, that assumption decreases the apparent rate of increase by less than 0.1% (Keyfitz 1977). We only report productivity for one breeding season. What effect does year-to-year variation in productivity have on the estimate of population growth? Prévost et al. (1978) reported productivities in the range 1.0–1.4 young per occupied nest. Those productivity rates give estimates of λ as 1.04 and 1.09, respectively. Hence, λ is fairly robust to different productivities in the commonly reported range. Those estimates of annual growth are close to the current 8–10% population increase observed along the northeast seaboard of the United States (Spitzer and Poole 1980).

Acknowledgments

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Increased Numbers and Productivity of Double-crested Cormorants, *Phalacrocorax auritus*, on Lake Ontario

IOLA M. PRICE[1] and D. VAUGHN WESELOH[2]

[1]Canadian Wildlife Service, Ottawa, Ontario K1A 0E7
[2]Canadian Wildlife Service, Ontario Region, P.O. Box 5050, Burlington, Ontario L7R 4A6

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From 1974 to 1982 Double-crested Cormorants (*Phalacrocorax auritus*) nesting on Lake Ontario increased from approximately 22 to 770 pairs, showing an average annual rate of increase of 56%. During the same time, productivity on Canadian colonies increased from zero to 1.3-1.4 young/pair. We believe the increased population size and productivity are the result of decreased contaminant levels. Population growth since 1974 can be explained by enhanced reproductive success and early first breeding, except in 1976, 1978 and 1979 when immigration must have occurred.

Key Words: Double-crested Cormorant, *Phalacrocorax auritus*, Lake Ontario, breeding success, contaminants, population dynamics.

From 1950 to 1974 the known Lake Ontario population of nesting Double-crested Cormorants (*Phalacrocorax auritus*) declined from approximately 218 to 22 nesting pairs (Tables 1A and 1B). No cormorants are known to have fledged from any Canadian colonies there from 1954 to 1977. In this paper, we report on the increase in the number of cormorants nesting on Lake Ontario since 1978 and on the first indication of "normal" productivity on at least one Canadian colony in 24 years. We also discuss the role of immigration versus enhanced natural production.

Methods

Annually from 1978 to 1982, one or both of us visited Scotch Bonnet, Snake, Pigeon and Little Galloo islands in eastern Lake Ontario during the nesting season (Figure 1). We also visited Salmon Island and Peter Rock on a less regular basis. We recorded the numbers of cormorant nests and the nest contents, and banded young when possible. However, over 99% of the nests on Little Galloo Island were in trees and it was impossible to record their nest contents (Blokpoel and Weseloh 1982).

Results

In 1978 IMP found four cormorant nests containing a total of nine eggs on Pigeon Island on 29 June. By 2 August the nests were abandoned and five eggs were found scattered on the ground. Four of the eggs had well-developed embryos, but two of these had been dead in the shell for a considerable time.

On Scotch Bonnet Island, G. Fox (Canadian Wildlife Service (CWS) personal communication) saw approximately 32 cormorants and found 6 nests containing 17 eggs on 21 June 1978. On 25 July, 29 adult cormorants were noted by DVW but only 3 nests remained. Two of these were empty but the third contained two young which we estimated to be 10-14 days old. The large number of adult cormorants showing attachment to Scotch Bonnet Island and the fact that most of the Herring Gulls (*Larus argentatus*) had finished nesting and had left the island suggested to us that the two young cormorants were likely to fledge. On 25 July DVW estimated 180-200 cormorant nests in trees on Little Galloo Island.

On Pigeon Island in 1979, we found 40 cormorant nests (37 on the ground and 3 in a tree) and an average clutch size of 2.8 eggs/nest (N = 35). We banded 56 large young and noted at least 4 others of comparable age (3-4 weeks). Chick mortality in cormorants is known to be low, i.e. 5% from time of hatch to fledging (Drent et al. 1964). In our experience, this figure seems too low. We estimated that from 60 young, three to four weeks old, 50 to 55 cormorants probably fledged, an average of 1.3-1.4 young/nest. This is well within the range of 1-2 young/nest for normally reproducing Double-crested Cormorants (Dunn 1975; DesGranges 1982), far above the 0.06-0.11 young/nest (Weseloh et al. 1983) for cormorants in Lake Huron during 1972, but less than the 2.1 and 2.4 per clutch on the Magdalen Islands during 1977 and 1978, respectively (Pilon et al. 1983). It represents the first normal productivity from a cormorant colony in Canadian Lake Ontario in 24 years.

In 1980-1982 the number of cormorant nests on Pigeon and Little Galloo islands continued to increase, and productivity on Pigeon Island appeared to be normal (Table 1B). However, Scotch Bonnet Island seemed to be of only marginal importance for

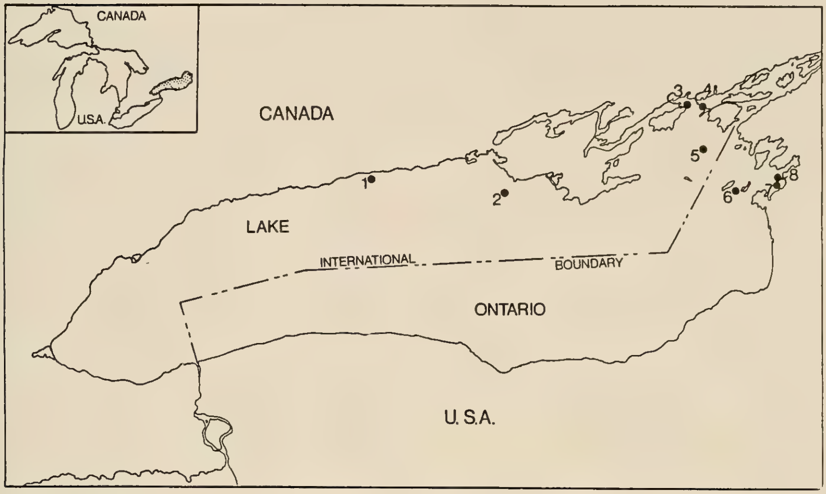

FIGURE 1. Cormorant colonies discussed in this study. 1. Peter Rock (43°56′N, 78°14′W), 2. Scotch Bonnet Island (43°54′N, 77°33′W), 3. Salmon Island (44°12′N, 76°36′W), 4. Snake Island (44°11′N, 76°33′W), 5. Pigeon Island (44°05′N, 76°33′W), 6. Little Galloo Island (43°51′N, 76°13′W), 7. Gull Island (43°53′N, 76°24′W), 8. Bass Island (43°55′N, 76°10′W).

nesting cormorants. In 1980 and 1981 fewer than 15 nests were constructed late in the season (mid-June), and all nests were subsequently abandoned. Late nest construction by colonial waterbirds is often associated with nesting attempts by immature or inexperienced birds (Ryder 1980).

The known nesting history of cormorants on Lake Ontario is detailed in Tables 1A and 1B. Counts are lacking for most colonies in many years and we are unsure of the accuracy of counts except our own. Neither side of western Lake Ontario contains habitat suitable for nesting cormorants. Thus, except for one small island near Port Hope (Peter Rock) all of the cormorant colonies in Lake Ontario are found at the eastern end. Although the number of islands there is small, unknown colonies could have existed during any of the years. Even so, it is apparent that during the 1950s and 1960s the population declined to between 20 and 60 pairs from a high of at least 218 pairs in 1950. It may have declined even further during 1972-73 to perhaps 3-10 pairs; we do not know if cormorants were nesting on Little Galloo then. This would have been the lowest population level since the species was first recorded nesting on the lake in 1938 (Baillie 1947).

From 1974 to 1978, the population of breeding cormorants on Lake Ontario increased from approximately 22 pairs to at least 202 pairs (Table 1B). Population figures from this period are fairly complete, lacking only records from Salmon Island and Peter Rock (very small islands which are not known to have had nesting cormorants between 1978 and 1982). From 1979 to 1982 the known Lake Ontario population increased from 315 to 770 pairs. Most of this increase was a result of the astronomical growth of the colony on Little Galloo Island.

Discussion

What factor(s) caused the cormorants' decline in numbers and productivity in the mid-1950s and their subsequent resurgence starting in the mid-1970s?

The Decline

Fishermen have accused cormorants of eating fish of commercial and recreational value, despite much evidence to the contrary, and they frequently destroyed nests, eggs and young (Omand 1947). In the Kingston area activities of fishermen probably caused the birds to abandon Snake and Salmon islands (Quilliam 1973). H.H. Southam, in conversation with M. Gilbertson (then of CWS, personal communication), stated that in the late 1950s and early 1960s fishermen shot cormorants and smashed eggs on Scotch Bonnet Island. Fortunately, this type of disturbance has now ceased (but see Weseloh and Struger 1985).

However, contamination by chlorinated hydrocar-

TABLE 1A. Lake Ontario Double-crested Cormorant nesting history, 1930s to 1959, Canada and United States.

	1930s	1938	1939	1940s	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1959
Scotch Bonnet Island																		
Nests	50[1]+	6[2]	40[3]	200[1]	PRES[2]	134[2]	PRES[4]			154[5]	PRES[4]		PRES[4]					
Eggs																		
Fledglings						40-70	50	5[4]	10[4]		7[4]		4	3[4]				
Snake Island																		
Nests									14[9]	19[9]				50[9]	24[9]	34[9]	0[9]	
Eggs																		
Fledglings														6 YG				
Salmon Island																		
Nests										11[9]								
Eggs																		
Fledglings																		
Peter Rock																		
Nests										27[10]			30[11]		4[11]			
Eggs													8		1			
Fledglings																		
Pigeon Island																		
Nests																		
Eggs																		
Fledglings																		
Little Galloo Island																		
Nests					0[16]					0[17]				0[18]				
Eggs																		
Fledglings																		
Gull Island																		
Nests					14[24]				20[25]	34[17]	PRES[26]	20[27]	PRES[18]	PRES[18]	PRES[28]			PRES[29]
Eggs																		
Fledglings														7-11				
Bass Island																		
Nests										0[17]								
Eggs																		
Fledglings																		

(1) H. H. Southam to M. Gilbertson, November, 1971; (2) Baillie 1947; (3) Snider 1942; (4) CWS banding data (possibly not the total number fledged); (5) Francis 1950; (6) CWS unpublished field notes; (7) G. A. Fox personal communication; (8) This paper, IMP, or DVW personal observation; (9) Quilliam 1973; (10) "20 adults perched on lighthouse railing" G. Francis field notes, personal communication to IMP; (11) E. R. Macdonald personal communication to IMP February 1980; (12) R. Hale unpublished field notes; (13) Edwards 1970; (14) "Soft-shelled eggs on ground" Edwards et al. 1963; (15) Edwards 1972; (16) Kutz 1946; (17) Belknap 1950; (18) Clinch 1954; (19) Belknap 1961; (20) Belknap 1968; (21) Chamberlaine 1978; (22) Chamberlaine 1975; (23) Scharf 1978; (24) Kutz and Allen 1947; (25) Calculated from remarks in Belknap 1951 and Barlow 1952; (26) Belknap 1951; (27) Barlow 1952; (28) Clinch 1955; (29) Clinch 1959; (30) Clinch 1963; (31) Clinch 1964; (32) Clinch 1965; (33) Gordon 1966; (34) Gordon 1967; (35) Clinch 1968.

TABLE 1B. Lake Ontario Double-crested Cormorant nesting history, 1961 to 1982, Canada and United States. See Table 1A for footnotes.

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
Scotch Bonnet Island																						
Nests											18[6]	5[6]	2[6]	0[6]	0[6]	0[6]	0[6]	6[7]	0[7]	2[8]	12[8]	0[8]
Eggs											26	2	1					17		5	11	
Fledglings											0?	0	0					2		0	0	
Snake Island																						
Nests																				0[8]	0[8]	
Eggs																						
Fledglings																						
Salmon Island																						
Nests																						
Eggs																						
Fledglings																						
Peter Rock																						
Nests												5[11]	1[12]							0[8]	0[8]	0[8]
Eggs												7	0									
Fledglings												?	0									
Pigeon Island																						
Nests	0[13]	3[13]	0[13]	0[13]	0[13]	0[13]	1[13]	0[13]	0[13]	2[13]	1[15]	0[8]	0[8]		0[8]	0[8]	0[8]	4[8]	40[8]	97[8]	168[8]	175[8]
Eggs		2	2[14]				3			3	1							9	98	21	4	70
Fledglings		0	0				0			0	0							0	55	166	259	260
Litte Galloo Island																						
Nests	0[19]							0[20]						22[21]	28[22]	76[23]	96[23]	192[21]	275[8]	276[8]	461[8]	595[8]
Eggs																						
Fledglings																						
Gull Island																						
Nests		19[30]	19[30]	19[31]	PRES[32]	PRES[33]	15-20[34]	PRES[35]								0[23]	0[23]					
Eggs																						
Fledglings																						
Bass Island																						
Nests			PRES[30]		PRES[32]											0[23]	0[23]					
Eggs																						
Fledglings																						

bons is the most likely cause of recent widespread reproductive failures among cormorants and other fish-eating birds on the Great Lakes (Keith 1966; Anderson and Hamerstrom 1967; Gilbertson 1974; Gilman et al. 1977; Price 1977; Teeple 1977; Weseloh et al. 1983). Similar effects of these contaminants are known on a worldwide basis (Koeman et al. 1972; Gress et al. 1973; Blus et al. 1974).

It is likely that persecution and toxic chemicals were jointly responsible for the decline in cormorant numbers in the 1950s and early 1960s. However, it is probable that toxic chemicals alone were responsible for the continuing decline and subsequent lack of productivity in the late 1960s and early 1970s. In the Canadian upper Great Lakes, reproductive success of cormorants was strongly depressed in populations with elevated levels of chlorinated hydrocarbon contaminants (Postupalsky 1978; Weseloh et al. 1983).

The Resurgence

In the early 1970s, conditions began to improve. In Lake Huron, Postupalsky (1978) and Weseloh et al. (1983 and *unpublished*) reported signs of declining contaminant residue levels in cormorant eggs and increasing reproductive success. Similarly, Weseloh et al. (1979) showed increased reproductive success in Herring Gulls from lakes Ontario and Erie during the period 1974-1978 at the same time that organochlorine residue levels were declining in their eggs. In Lake Ontario between 1971 and 1981, DDE levels in cormorant eggs decreased 50% from 9.6 ppm (wet weight, Scotch Bonnet Island, N = 7) to 4.8 ppm (Pigeon and Little Galloo islands, N = 20) and eggshell thinning decreased from 24% to 6% (CWS *unpublished*). We believe that a reduction in contaminant levels is the major factor in the recently increased productivity of cormorants on Lake Ontario.

A second factor is the appearance of Alewives (*Alosa pseudoharengus*) and Rainbow Smelt (*Osmerus mordax*) in the 1870s and 1930's, respectively, in Lake Ontario (Scott and Crossman 1973). Both species are abundant and available to the cormorants. We believe that first persecution and then contamination outweighed the positive effect of abundant food and that nest site availability has not been a limiting factor.

The Rate of Increase in the Lake Ontario Cormorant Population

Our data show that the cormorant population increased from approximately 22 pairs in 1974 to 770 pairs in 1982 (Table 1B). This is an average annual rate of increase (growth rate) of nearly 56% (Figure 2). During this time between-year growth rates varied

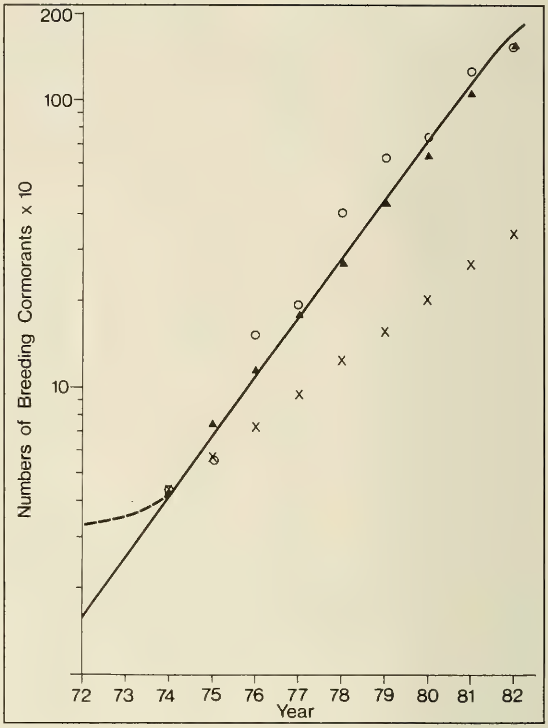

FIGURE 2. Actual and modelled population growth of Double-crested Cormorants on Lake Ontario: "0" = population size, "X" = population growth under less stringent conditions as described in model 2 (37% per year), "▲" = population growth as calculated in model 3 (56% per year).

from 19% to 171% (Table 2). This rapid increase prompts the question: "Could an average annual growth rate of 56% by achieved without immigration?" To answer this question we examined the productivity and mortality parameters of the species.

In a stable population, Double-crested Cormorants are considered to breed at 3 years of age, raise one young per pair and suffer 70% pre-breeding mortality and 15% annual adult mortality (Hickey 1952; Palmer 1962; Ludwig 1985; S. Brechtel, University of Alberta, personal communication). Between 1974 and 1982, assuming no immigration, these parameters would have maintained the population at a constant level showing no growth (Model 1, Table 3).

In times of rapid population increase, some colonially-nesting waterbird populations have reproductive parameters different from those of stable populations, e.g. Ring-billed Gulls (*Larus delawarensis*) (Ludwig 1974). If this were true for cormorants on Lake Ontario, we might witness first breeding at 2

TABLE 2. Growth and calculated production and immigration of Lake Ontario Cormorant population[1].

	A	B	C	D		E	F
	Size of breeding population (No. nests × 2)	No. of young fledged based on model	No. of "young" reaching adulthood from production 2 years previous	Growth of breeding population since previous year		Years when D > C; immigration probably occurred	% of growth attributable to immigration (D-C)/D
				#	%		
1974	44	62	UNK	UNK	UNK	—	
1975	56	78	UNK	12	27	?	
1976	152	213	43	96	171	X	55
1977	192	269	54	40	26		
1978	404	566	147	212	110	X	31
1979	630	882	186	226	56	X	18
1980	750	1050	391	120	19		
1981	1282	1795	609	532	71		
1982	1540	2156	725	258	20		

[1]The model assumes a fledgling rate of 2.8 young/pair (1.4 young/individual), 31% pre-breeding mortality, 10% annual adult mortality, first breeding at 2 years of age, and all adults breeding each year.

years (i.e. the young from any year's production are incorporated into the breeding population two years hence); productivity at or near 2.5 young per pair (close to the Great Lakes' average (cf. Weseloh et al. *unpublished*); pre-breeding mortality reduced from 70% to 50% or even less and a decrease in adult mortality from 15% to 10% (or less) per year. Such changes are known in species whose population size is controlled by density-dependence (Lack 1954). Even under these less stringent conditions, however, the resulting average annual growth rate is only 37%, considerably less than the observed rate of 56% (Figure 2 and Model 2, Table 3). To reach the observed growth rate, exclusive of immigration, the

TABLE 3. Growth rates* for six different population models of Double-crested Cormants. Model 1 = stable population; model 2 = less stringent conditions suggested in density-dependent mode (see text); models 3 and 4 = two sets of conditions which will result in 56% annual growth rate; model 5 = parameters from model 3 with breeding at age 3; model 6 = mortality parameters from model 3 with known productivity from Pigeon Island 1982.

	Age in years at first breeding	Young fledged per pair	Pre-breeding mortality	Annual adult mortality	Growth rate
Model 1	3	1.0	70%	15%	0
Model 2	2	2.5	50%	10%	37%
Model 3	2	2.8	31%	10%	56%
Model 4	2	3.0	40%	5%	56%
Model 5	3	2.8	31%	10%	44%
Model 6	2	1.7	31%	10%	35%

*The growth rate calculation is based on a population of 44 individuals (22 nests) in 1974 and the various calculated populations in 1982 (8 years later). A constant population of 44 breeding individuals is used in calculating the recruitment from years prior to 1974.

cormorants on Lake Ontario would have to achieve much higher productivity and lower mortality parameters, such as breed at two years of age, fledge 2.8 young/pair, and experience pre-breeding and annual adult mortality of 31% and 10%, respectively (or some combination equivalent to this, Model 3, Table 3). Models 4, 5 and 6 show the effects of very small changes in demographic factors on population growth.

Are these parameters possible for Lake Ontario cormorants? Of the four field-determined parameters listed above, we have current data from the Great Lakes for only productivity (i.e. young fledged per pair). Productivity on Pigeon Island in 1982, when approximately 23% of the Lake Ontario population nested there, was approximately 1.7 young/pair (Weseloh et al. *unpublished*). We do not have any productivity data for Little Galloo Island since, until recently, all nests were located in trees. However, we have recorded productivity as high as 3.2 young/pair for cormorants on Big Chicken Island in Lake Erie in 1979 (CWS, *unpublished*). If Little Galloo cormorants were as successful, productivity for Lake Ontario cormorants could be just over 2.8 young/pair.

For the other parameters, i.e. age at first breeding, and pre-breeding and annual adult mortality, there are no data available from rapidly expanding cormorant populations. On Mandarte Island, British Columbia, where the Double-crested Cormorant population was expanding at only 8.1% per year, van de Veen (1973) found that 16.5% of the breeding population was two years old (4.7% was one year old), mortality during the first two years was 64.5%, and annual adult mortality was 15.1%. To what extent these figures might be modified in a rapidly expanding population on the Great Lakes remains to be determined. However, we conclude that the calculated productivity and mortality parameters necessary for the witnessed overall growth of the Lake Ontario cormorant population are plausible and may have been in effect over most years of this study. Hence it does not appear that immigration need have occurred to explain the population growth (but see below).

In consideration of immigration, however, one remaining question should be answered: "Is there any evidence that immigration might or needed to have occurred?" From data in Table 1B and using the population parameters of 2.8 young per pair, breeding at age 2 and 31% pre-breeding mortality and 10% annual mortality, we can calculate the growth in the breeding population and the amount of recruitment per year (Table 2).

We do not know when cormorants started nesting on Little Galloo Island, the largest Lake Ontario colony, nor how many were involved initially. It appears that between 1968 and 1974 cormorants from Gull and/or Bass islands may have moved to Little Galloo Island, 4.3 km farther out in Lake Ontario (Table 2). Nevertheless, we do not know the size of the nesting population prior to 1974 or the number of young cormorants which would have reached breeding age in 1974 or 1975. Beginning in 1976, however, both of these figures are available or can be calculated. In three of seven years, 1976, 1978 and 1979, the actual growth of the cormorant population on Lake Ontario, 171%, 110% and 56%, respectively, far exceeded the calculated production and survival of young from two years previous (Table 2). Thus, in those three years, substantial immigration (up to 55% of the year's growth) must have occurred, unless other colonies had existed to produce the extra young two years earlier.

The rapid growth that we have documented in the cormorant population of Lake Ontario is occurring throughout the Great Lakes (Scharf and Shugart 1981; Ludwig *unpublished*; Weseloh et al. *unpublished*). Ludwig (1985) has calculated that from 1973 to 1981 the cormorant population of the Great Lakes as a whole had an average annual growth rate of 44%. Outside the Great Lakes, Double-crested Cormorant populations have shown substantial recent increases on the Atlantic coast (Hatch 1982; G. Hogan. Cormorant census. University of Prince Edward Island. MS. [1983] 12 pp.; Milton and Austin-Smith 1983), St. Lawrence River and Estuary (DesGranges and Reed 1981; DesGranges 1982; DesGranges et al. 1984), in the Prairie Provinces (Weseloh et al. 1978; Roney 1978, 1979) and on the Pacific coast (Vermeer and Rankin 1984).

Most authors studying Great Lakes cormorant populations suggest that much of the increase in cormorant numbers there is due to a surplus production of young from local colonies (e.g. on Little Galloo Island) and to the immigration of birds from outside the Great Lakes (Blokpoel et al. 1980). Our data and calculations show that the Lake Ontario (and Great Lakes) cormorants may have the intrinsic ability to increase at a sustained annual rate as high as 56%. However, in years when the annual increase is greater than the amount of recruitment from two years previous, immigration must have occurred. Where immigrants come from remains unanswered, since most colonies across Canada and the U.S. are also increasing (Vermeer and Rankin 1984).

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Relative Age Determination of Coyotes, *Canis latrans*, from Southern Quebec

Yves Jean, Jean-Marie Bergeron, Sylvie Bisson, and Brigitte Larocque

Département de biologie, Faculté des sciences, Université de Sherbrooke, Sherbrooke, Québec J1K 2R1

Jean, Yves, Jean-Marie Bergeron, Sylvie Bisson, and Brigitte Larocque. 1986. Relative age determination of Coyotes, *Canis latrans*, from southern Quebec. Canadian Field-Naturalist 100(4): 483–487.

Comparison of cementum annuli counts using a grinding method and standard histological preparations gave similar (± 1 annulus) estimates in 61% of the 38 adult Coyotes (*Canis latrans*) examined. Readability of canine tooth sections prepared by the easy and rapid grinding technique was as good as that for sections prepared by the time-consuming histological procedures. Moreover, inter-observer variation did not differ between the two techniques. Pulp ratio measurements easily separated juveniles from adult animals on the basis of a separation point at 0.48.

Key Words: Coyote, *Canis latrans*, histology, cementum annuli, age determination, Quebec.

Reliable ageing techniques are needed by wildlife managers who, at times, have to make decisions based on the age structure of a population. Counts of cementum annuli on the roots of certain teeth, based on histological sections, have been used for many species including Coyotes, *Canis latrans* (Linhart and Knowlton 1967), and appear quite reliable (Grue and Jensen 1979). However these may be time consuming. Some, like Nellis (1975), have argued for alternative methods to process larger samples in less time. Observations of polished tooth sections using reflected light is a rapid technique which has been successfully used to age numerous mammalian species by annuli counts (Fancy 1980). To our knowledge, it has never been applied to Coyotes. Measurements of pulp cavity ratios have also proved useful in separating juveniles from older animals (Knudsen 1976) but no data exist for Coyotes from southern Quebec. Hence, we present 1) a comparison of the accuracy of annuli count methods from tooth sections prepared by histological and grinding procedures for adult animals and 2) a verification of the usefulness of pulp ratios to separate juveniles from older Coyotes of southern Quebec.

Methods

Lower canines of 229 Coyotes trapped in the Eastern Townships, southern Quebec (Jean and Bergeron 1984) between May 1979 and March 1981 were extracted by boiling the anterior portion of the mandibles for 20 minutes. Eleven of the animals were pups with milk teeth. Root tips of the remaining 218 Coyotes were examined for the presence of an open root canal. The canines were then severed at the neckline using a 1.6 mm thick carborundum saw. The neckline was chosen because it could be easily identified on every tooth. The antero-posterior length of the pulp cavity (a) and that of the tooth itself (b) were measured at the neckline under a calibrated binocular (0.1 mm) to establish the pulp ratios (a/b). Because no significant differences were found between ratios from the left and right canines ($t = 1.90$, $P > 0.05$), we measured both and used the mean for analysis. Furthermore, we pooled the data for both sexes since no significant differences were found between juvenile males and females ($F = 4.53$, $P > 0.05$) and between adult males and females ($F = 0.21$, $P > 0.05$).

Cementum annuli were counted on the two lower canines of 43 adult Coyotes. Sections of one tooth were processed through histological routines (Linhart and Knowlton 1967), while the other canine was prepared by a grinding technique (Ouellet 1977; Jean 1980). Annuli counts were performed independently by two observers under a microscope at 10X for the grinding technique and at 40X and 100X for the histological method. Ten slides per tooth were processed for histological studies, and the final count was provided by the best preparation (slide).

Results and Discussion

Tooth sections processed through histological routines were not as clear as we expected from literature. Most of the time they were clearly readable on one side of the tooth only or at the apex of the root. Annuli were often diffused or compressed, rendering counts difficult. Cementum annuli from grinding procedures appeared as dark brown lines that were rarely visible all around the perimeter. However, there was at least one portion where all annuli were clearly separated. In both methods there were problems with some irregularities which could produce errors. The most common was the presence of "faint lines" (reported previously by Nellis et al. 1978) present

between true annuli on 17 Coyotes (45%). In 3 animals (8%), a bifurcation of an annulus into two small annuli was observed.

Overall, the histological method did not give more accurate results than the grinding technique. Like Gasaway et al. (1978), we used a subjective readability index to compare both methods (Table 1). No significant differences (Mann-Whitney U-test: $Z = -1.784$, $P > 0.05$) between the two methods were found in the readability indices. Both showed similar percentages of medium readability, although tooth sections prepared by the grinding technique offered a higher percentage of excellent readability. Many preparations required subjective interpretation by the observers but both methods produced similar degrees of inter-observer error (Table 2). In 37% of counts on histological sections there was perfect agreement between observers, whereas in 30% of counts on ground sections there was perfect agreement. These percentages increased to 61% and 70%, respectively, when an error of $\pm$ 1 annulus was allowed in the sum. Agreement reached 95% for both methods when using a range of $\pm$ 3 annuli. These results compare well with those of experienced readers (Nellis 1975; Gasaway et al. 1978) and point out that variation in interpretation can be an unavoidable source of error in such studies.

Only 12 Coyotes (32%) showed exact agreement in the number of annuli estimated by both methods (Figure 1). This increased to 61% (23 Coyotes) when allowing an error of $\pm$ 1 annulus. Annuli counts differed by 2 annuli in 5 animals (13%) and by 3 annuli in 3 animals (8%). In the remaining 7 Coyotes (18%), differences ranged from 4 to 8 annuli. In these latter cases tooth sections had been badly prepared by histological or grinding procedures, making accurate counts difficult. In several cases the ground tooth sections gave consistently higher counts than those from the standard histological methods (Figure 1). Longitudinal sections of teeth which are commonly used in histological exams allow the observation of the entire length of an annulus. This is thought to help in the detection of numerous sources of errors like those reported by Fancy (1980). Obviously, the lack of wild known-aged specimens does not permit us to expand on these potential sources of errors [but see Fancy (1980) for review]. The only captive examined was a 3 year old female with 2 cementum annuli.

Ageing large cohorts of Coyotes can be accomplished more quickly if juveniles can be readily separated from adults. Data from this study showed that permanent canines were present in all juveniles after August and that root tips were closed by 9 months of age. This led us to test the value of pulp ratios as separation criteria using 218 animals that had been previously aged by annuli count techniques. A decreasing ratio with age was recorded, varying from 0.81 for 3 pups to 0.09 for 4 adults. The shape of the canal changed from oblong in pups to circular in older Coyotes. A fourth degree polynomial analysis showed a nonlinear relationship with age, consisting of a drastic decline in pulp ratios when animals are young to a slight decrease when they become older (Figure 2).

TABLE 1. Comparison of the readability index between tooth sections of 43 adult Coyotes prepared by histological and grinding techniques.

Technique used	Readability index[1] [N (% of total)] 0	1	2	3	$\bar{x}$
Histology	5 (12)	11 (26)	19 (44)	8 (19)	1.70
Grinding	0	8 (19)	22 (51)	13 (30)	2.12

[1]Readability scores [based on Gasaway et al. (1978)].
0 not readable.
1 barely readable, low contrast.
2 readable, medium contrast, some difficulties in counting.
3 lines distinct, high contrast, easy counting.

TABLE 2. Comparison of agreement values between two observers in annuli counts of tooth sections prepared by histological and grinding techniques.

Range of differences in annuli counts	Number of specimens agreed upon (%) Histology[1]	Grinding[2]
0	14 (37)	13 (30)
1	9 (24)	17 (40)
2	7 (18)	7 (16)
3	6 (16)	4 (9)
>3	2 (5)	2 (5)

[1]N = 38 specimens since 5 tooth preparations had to be discarded.
[2]N = 43 specimens since all Coyotes were aged by this technique.

Differences between such *a posteriori*-formed age groups were then tested with a univariate analysis of variance. Unfortunately, we were unable to include juveniles and yearlings in the test because of scarcity of data for the latter group. Nevertheless, the 3-5, 6-8 and 8-11 year old groups showed significant differences ($F = 10.94$, $P < 0.01$) between their respective pulp ratios. In spite of such differences between animals older than 3 years, we agree with Grue and Jensen (1976) and Johnson et al. (1981) who think that this does not solve the problem of

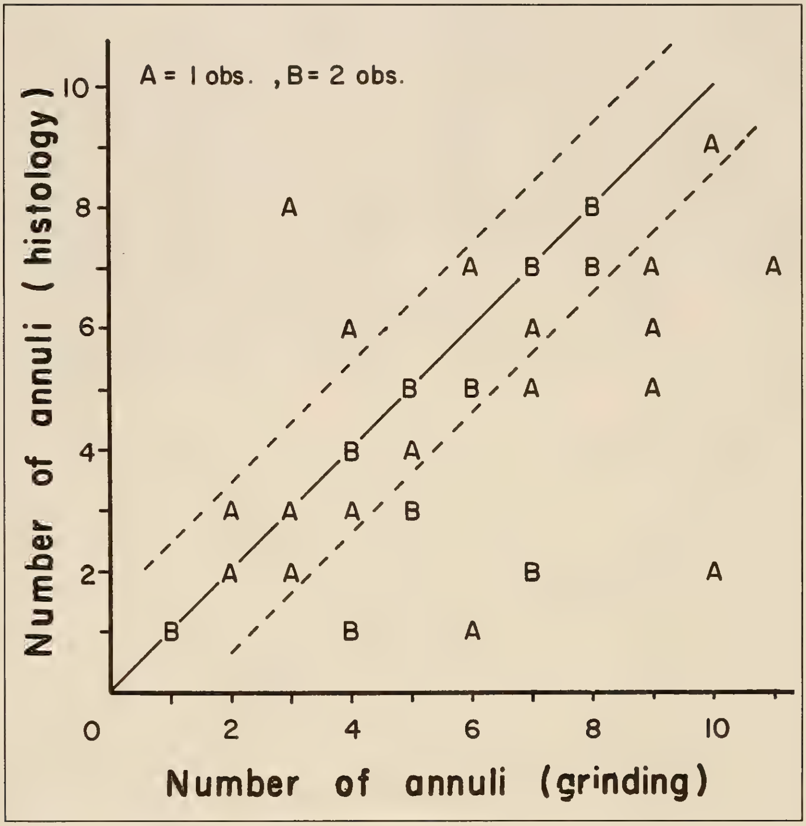

FIGURE 1. Comparison of cementum annuli counts in 38 adult Coyotes using tooth sections prepared by grinding and histological procedures. Dashed lines include animals from inter-technique errors of ± 1 annulus.

accurately ageing the adult portion of the population because most of the time it includes a large overlap of age groups. Moreover, we do not yet know if the size of the pulp cavity is sufficiently reliable to use as a standard parameter for ageing populations throughout the range of *Canis latrans*.

After comparing pulp ratios and capture dates for juvenile Coyotes, we observed that the pulp ratios decreased very rapidly up to the winter months and that none was less than 0.48 at this period. This is a little higher than the ratio of 0.32 established by Knudsen (1976) for Utah Coyotes. A subsequent check of the cementum annuli analyses of the 37 juveniles caught in January and February revealed a lack of an annulus in 34 animals (92%) and a misleading line that could be interpreted as an annulus in only 3 (8%). Re-examination of the group of 10 animals with pulp ratios between 0.37 and 0.47 (Figure 2) showed that one of those animals that had been captured the previous August had no annulus, and was therefore a yearling. The remaining ones that had been captured between January and March had from one to three annuli.

This points out the degree of difficulty in ageing winter captures. Separation points undoubtedly change through the year (Knudsen 1976) so that collection dates must be carefully recorded. Since most of the trapping in Quebec occurs mainly between November and January, we conclude that the separation point of 0.48 in pulp ratios can be safely and quickly used to separate juveniles from adults. If time and money are available, we suggest using cementum annuli counts for animals captured later than January because Coyotes in their first winter of life can have one cementum annulus (Allen and Kohn 1976).

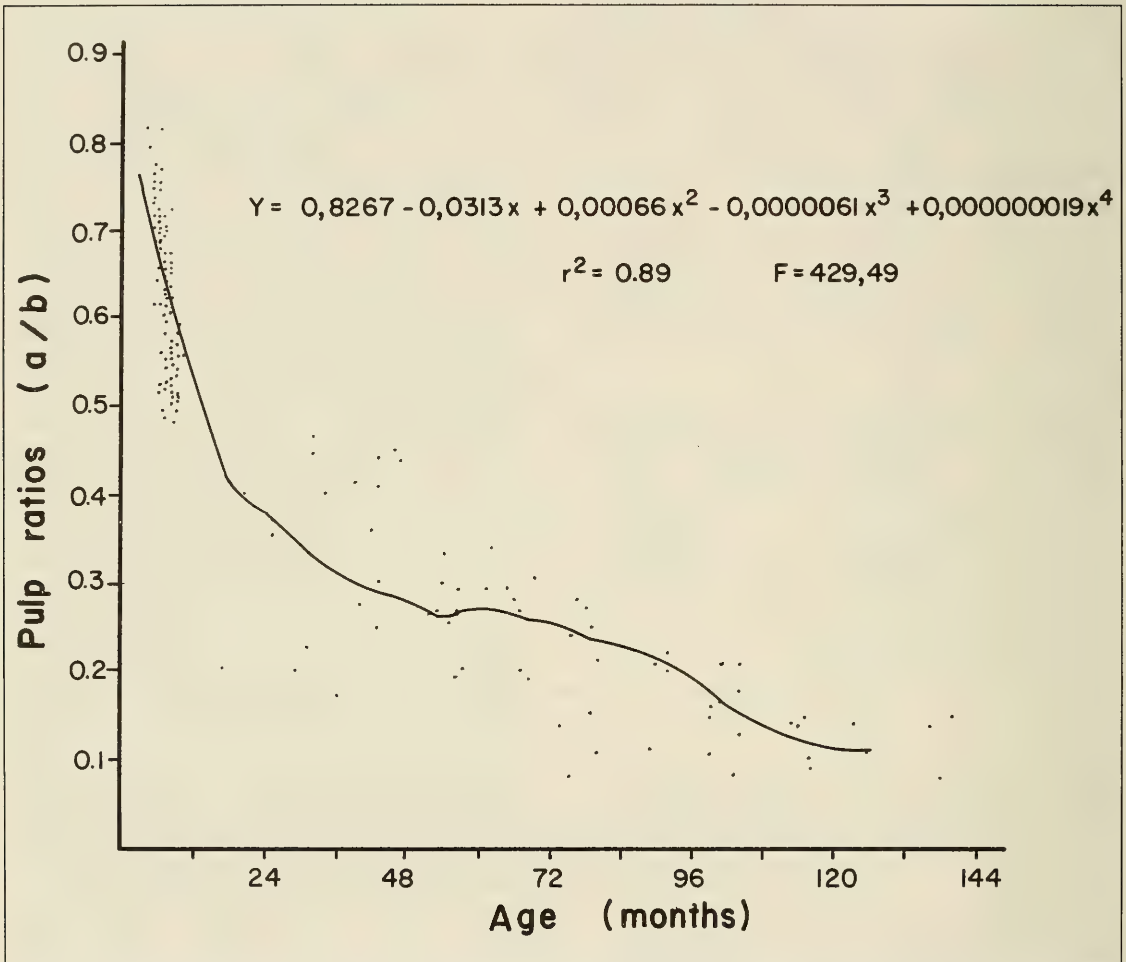

FIGURE 2. Polynomial regression analysis of pulp ratios and estimated age (by cementum annuli counts) of Coyotes.

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Disruption of Rough Fescue, *Festuca hallii*, Grassland by Livestock Grazing in Riding Mountain National Park, Manitoba

GARRY C. TROTTIER

National Parks Research Group, Canadian Wildlife Service, 4999 - 98 Avenue, Edmonton, Alberta T6B 2X3

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Rough Fescue (*Festuca hallii*) grassland was studied to determine the impact of grazing by livestock and to assess recovery of depleted range. Light to moderate grazing generally reduced the abundance of, and caused dominance shifts among, the climax grass species. Forbs increased at the expense of grasses. At heavily grazed sites, native grasses were eliminated and a replacement community of Kentucky Bluegrass (*Poa pratensis*) evolved in equilibrium with the grazing pressure. Species diversity was markedly reduced and there was little evidence of recovery to pristine conditions after termination of grazing. The management implications of these data are discussed in relation to native grassland protection and rehabilitation.

Key Words: Rough Fescue, *Festuca hallii*, Kentucky Bluegrass, *Poa pratensis*, livestock grazing, endangered habitat management, Riding Mountain National Park, Manitoba.

Rough Fescue grassland occupies the northern extremes of the North American Great Plains. It was designated as the seventh grassland association of the North American grassland formation within the classification of Weaver and Clements (1938) by Moss and Campbell (1947) working in Alberta, and by Coupland and Brayshaw (1953) based on studies in Saskatchewan. The taxonomy of Rough Fescues was recently revised by Pavlick and Looman (1984) into three taxa, *Festuca altaica, F. campestris (F. scabrella* var. *major*) and *F. hallii.*

The Rough Fescue association is found largely in Canada (Johnston 1958) and most frequently now as prairie openings in the Aspen Parkland zone extending from west-central Alberta to southwestern Manitoba (Moss and Campbell 1947; Coupland and Brayshaw 1953; Bird 1961; Coupland 1961; Looman 1969, 1981). Disjunct stands also persist in south-central British Columbia, in southwestern Alberta along the eastern slopes of the Rockies, as islands in the southern plains on benchlands and upper slopes of the Hand Hills, Cypress Hills, Milk River Ridge, Wood Mountains, the Duck and Riding mountains, and in North Dakota, Montana and Oregon (Looman 1969, 1981).

Much of the former extent of Rough Fescue grasslands included the productive black soil zone of the northern Great Plains and the Aspen Parkland (Moss and Campbell 1947; Coupland 1961). Along with the True Prairie and Tall Grass Prairie areas of southern Manitoba, Rough Fescue grasslands were the first areas to be converted to farmland during the early settlement period. Consequently, only where the growing season was too short for cereal crops or where rocky soils and rugged terrain prevailed has the Rough Fescue grassland persisted.

Rough Fescue grassland is a significant feature of the western Canadian heritage but may be an endangered biological system and could follow the True Prairie into near extinction. Of the estimated 20 000 km^2 of Rough Fescue grassland remaining in Canada, 90% has been greatly or moderately modified by livestock grazing and by haying (Looman 1969).

Perhaps the most pristine stands of this plant association are protected in three Canadian national parks: Riding Mountain (Blood 1966a), Prince Albert (Carbyn 1971), and Waterton Lakes. However, demands for emergency grazing privileges in those areas during the 1977 drought and Parks Canada fire control policy suggest the need for information on the successional dynamics of the Rough Fescue grassland so that vegetation management decisions can be made which ensure its conservation.

Domestic livestock grazing was allowed in Riding Mountain National Park until 1969. Range studies conducted from 1961 through 1963 demonstrated the need to end grazing in the park (Blood 1966a). In 1973 an additional range evaluation was conducted to determine the effect of grazing on the Rough Fescue grasslands and to monitor their recovery following termination of livestock grazing (G. C. Trottier. 1974. Range studies, Riding Mountain National Park. Unpublished Canadian Wildlife Service Report, Edmonton. 89 pp. 2 volumes). This paper summarizes some results from the latter study and discusses pertinent management considerations.

Description of the Study Area

Riding Mountain National Park is a 2974 km^2 forested highland in southwestern Manitoba 225 km

northwest of Winnipeg and 177 km north of the International Boundary. The park is a natural wildland consisting of forested, low hills and catchment basins. It is completely surrounded by farmland.

The eastern edge of Riding Mountain rises abruptly 427 m above the surrounding plain, and is part of the Manitoba escarpment. Most of the park, however, is situated above the escarpment on the Second Prairie Steppe of the Great Plains (Ehrlich et al. 1956). Elevations average 610 m with a range of 319 m to 756 m on the escarpment.

The irregular surface features create a fine-grained interspersion of ponds, marshes and lakes within the upland areas. Disruptive factors such as wildfire, logging, livestock grazing, and haying have contributed to the variation in vegetation (Bailey 1968). Consequently, the park consists of a patchwork of climax and subclimax vegetation of several types, resulting in high habitat diversity in all areas.

The park is included in the Boreal Mixedwood Forest Region (Rowe 1972). The flora consists of plants of three major vegetation zones: the Boreal Forest, the Eastern Hardwood Forest, and the Prairie Grasslands, reflecting post-glacial recolonization by floral complexes from the northwest, south and east (Love 1959). About 2.5% of the park consists of grassland (Bailey 1968), of which about one-third is native grassland of the Rough Fescue type (Figure 1) as described by Blood (1966b). The remainder is upland meadow of Slender Wheat Grass–Kentucky Bluegrass (*Agropyron trachycaulum–Poa pratensis*) which resulted from removal of forest cover by wildfires, and lowland meadow of pure sedge (*Carex* spp.) or mixtures of slough grasses (*Glyceria* sp., *Calamagrostis* spp.) and sedge.

Rough Fescue grasslands are an important habitat for the large Elk (*Cervus elaphus*) herd protected within the park. Rough Fescue is a key winter forage for Elk (G. C. Trottier, unpublished data) and important Elk winter ranges contain a significantly greater proportion of grasslands than areas little used by Elk (Rounds 1981).

Livestock Grazing History

Riding Mountain was first protected in 1895 when it was set aside as a Dominion Forest Reserve to conserve the remaining forests and wildlife in the

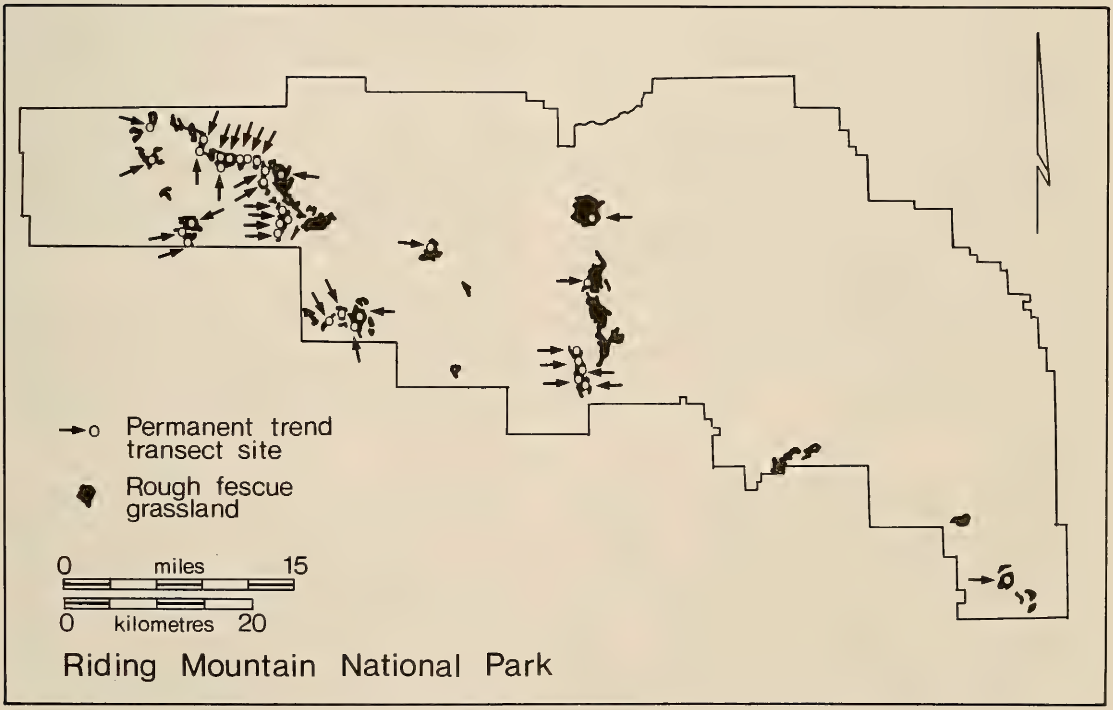

FIGURE 1. Distribution of Rough Fescue grassland, Riding Mountain National Park.

region from human settlement. Timber resources were managed and harvested, fire protection was enhanced, and consumptive use of wildlife was controlled. This situation continued through 1933 when Riding Mountain officially became a national park.

Livestock grazing was strongly encouraged in the forest reserve in order to reduce the fire hazard. The Chief Dominion Forester referred to grazing in his report of 1910 to the Director of Forestry, Canada Department of the Interior, as follows: "It is desirous for it tends to reduce the fire hazard through removal of carryover". Beginning in 1914-1915, 473 cattle and eight horses grazed the reserve, but the Chief Forester felt that 10 000 head could range in the grasslands that were available, and continued to encourage the public to apply for permits. Grazing peaked in 1919-1920 when 4628 cattle and 118 horses were placed on the range. Thereafter, stocking rates declined because of the Great Depression and the eviction of several ranching operations when national park status was achieved in 1933 (park files).

Seasonal livestock grazing continued until 1969 when the practice was eliminated because it violated national park principles and was found to be detrimental to native vegetation (Blood 1966a). Blood (1966a) determined that approximately 1375 cattle and 35 horses grazed under permit in 1962. This rate was similar to that during the 1950s and 1960s (park files).

The grass–forb ranges were the key areas for grazing (Blood 1966a). Grazing permits varied in duration from two to five months with mean turnout occurring by 1 June. Livestock grazed 324 km^2 or 10% of the park; however, this took place over essentially 50% of the Rough Fescue grasslands (Blood 1966a).

Grazing pressure was unevenly distributed, largely due to active herding. Over the long term, several contiguous overgrazed-to-non-grazed areas resulted. Grazing permits seldom changed hands, essentially remaining in control of local families for many years. Each permit-holder traditionally turned cattle onto the same range each year.

Methods

Changes in vegetation composition brought about by livestock grazing were determined by selecting sample stands according to the following criteria:

(1) that each stand selected be homogeneous in terms of vegetation composition and habitat conditions;

(2) that sample stands be in upland grasslands within the grazed areas outlined by Blood (1966a) and at sites where Blood had previously measured livestock grazing utilization and range condition in 1962 and 1963;

(3) that stands be selected so as to sample pristine Rough Fescue meadows, and upland meadows contiguous with pristine areas but more recently used for livestock grazing (at least since 1933).

Vegetation composition was determined in August 1973, using the "vertical point quadrat method" (Levy and Madden 1933) modified by placing pins at 30.5 cm intervals along a 30.5 m transect for a total of 100 points. In all, 3300 points were sampled over 33 stands and all foliage hits were recorded according to the method of Johnston (1957).

Blood (1966a) measured herbage use by livestock in 1962 and 1963 at a large number of sites in the park, 33 of which were sampled for vegetation composition in this study during 1973 (Figure 1). I concluded that the herbage use measured by Blood was representative of annual grazing pressure at the 33 sample stands over several years because the grazing permit records (park files) indicated only slight annual variation in the number of livestock on the ranges during the 1950s and 1960s. Therefore, I calculated mean herbage use for each sample stand from Blood's field data using the measured values for the two sample years — 1962 and 1963. On that basis the 33 sample stands were each assigned to one of five classes representing increasing herbage use by livestock: Slight grazing (0-5%), Light grazing (6-25%), Moderate grazing (26-50%), Heavy grazing (51-75%), and Severe grazing (> 75%). The number of sample stands in each grazing class was as follows: Slight — 6, Light — 3, Moderate — 14, Heavy — 6, and Severe — 4.

Differences in the foliage cover of grasses and forbs between classes of stands were tested using the Kruskal-Wallis test (Conover 1980). For those species with significantly different class values a procedure of multiple comparisons (Conover 1980) was applied to determine which pairs of sample populations tended to differ.

Botanical nomenclature follows Scoggan (1957) and Pavlick and Looman (1984). Vascular plant identifications were verified by staff of the Plant Research Institute, Agriculture Canada, Ottawa. Voucher specimens were deposited in the Herbarium, Riding Mountain National Park.

Results

Species composition of stands in the respective grazing classes varied from that typical of pristine Rough Fescue grassland to complete elimination of the typical species assemblage and replacement by species-depauperate communities (Figure 2). Rough Fescue was found at 24 of the 33 sample sites. Those sites which did not support this species were physiographically similar to and continuous with sites dominated by Rough Fescue. Therefore, it was

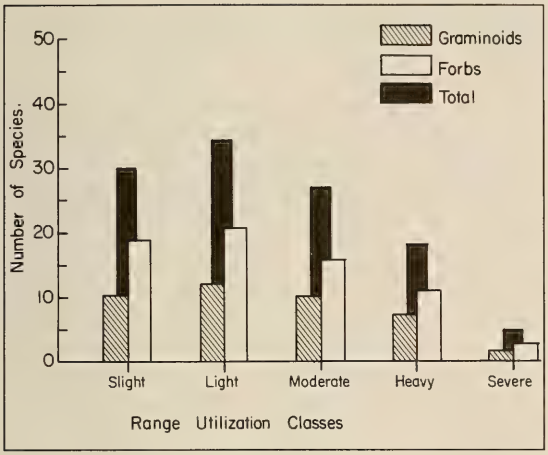

FIGURE 2. Number of species (by growth form) recorded by vertical point sampling in stands typical of five livestock grazing utilization classes of Rough Fescue grassland, Riding Mountain National Park, 1973.

hypothesized that all sites sampled were, at one time, representative of Rough Fescue grassland and that differences in vegetation composition indicate the impact of different grazing rates over the long term.

Stands in class 1 were ungrazed or slightly grazed by livestock since the mid 1930s. The dominant Rough Fescue canopy (Table 1) was interspersed by a dense layer of litter composed almost exclusively of native perennial grasses.

Foliage cover of Rough Fescue in lightly grazed stands was not significantly different than in slightly grazed stands but Kentucky Bluegrass cover was significantly greater (Table 2). The number and cover of grass and forb species in lightly grazed stands was greater than in slightly grazed stands (Table 2, Figure 2); therefore, light grazing probably opened the grass sward through reduced litter accumulation.

Moderately grazed stands sustained 26 to 50% herbage removal and had significantly less Rough Fescue and more Kentucky Bluegrass than the less heavily grazed stands (Table 2). Total species was less and total grass foliage cover was less than in pristine stands.

Heavily grazed stands sustained 50 to 75% herbage removal. Four of the six stands had no Rough Fescue, while the remaining two had less than one-third the Rough Fescue cover of pristine stands. Foliage cover of Western Porcupine Grass (*Stipa spartea* var. *curtiseta*) was less than in slightly grazed and lightly grazed stands (Table 1). June Grass (*Koeleria cristata*) was also significantly reduced where herbage removed exceeded 50%, whereas Kentucky Bluegrass cover was maximized along with Slender Wheat Grass, resulting in a replacement community dominated by these two species. Grass and foliage cover was greater than in less heavily grazed stands (Table 1). Overall species diversity was greatly reduced (Figure 2).

Severely grazed stands were areas of concentrated cattle use usually at salt blocks and watering sites. The combined pressure of grazing and trampling

TABLE 1. Mean foliage cover of dominant grasses and forbs on Rough Fescue ranges characterized by five different rates of livestock grazing, Riding Mountain National Park, 1973.

	Mean foliage cover (%)				
Taxon	Slight use	Light use	Moderate use	Heavy use	Severe use
Grasses					
Slender Wheat Grass	11.0	8.7	16.9	28.5	2.0
Rough Fescue*	58.7	43.3	16.9	8.5	0
Kentucky Bluegrass*	5.2	20.3	46.1	78.7	74.0
June Grass*	13.5	9.0	12.4	4.8	0
Western Porcupine Grass*	8.2	23.7	10.0	6.7	0
All grasses	119.0	117.0	107.0	142.0	76.0
Forbs					
Yarrow	5.2	3.7	8.7	7.2	1.8
Smooth Aster*	7.5	14.0	3.4	2.8	0
Northern Bedstraw	5.7	10.3	7.4	6.6	2.3
American Vetch*	4.0	1.3	11.4	11.3	0
All forbs	62.0	91.0	83.0	89.0	35.0

Herbage use class: Slight (0-5%), Light (6-25%), Moderate (26-50%), Heavy (51-75%), Severe (> 75%).
*Mean foliage cover significantly different among use classes (Kruskal-Wallis test), $P < 0.05$.

TABLE 2. Multiple comparison matrix of within-species foliage cover differences for five classes of livestock grazing utilization in Rough Fescue grasslands, Riding Mountain National Park, 1973.

	Herbage use			
	Light	Moderate	Heavy	Severe
Rough Fescue				
Slight	NS	S	S	S
Light		S	S	S
Moderate			NS	S
Heavy				NS
Kentucky Bluegrass				
Slight	NS	S	S	S
Light		S	S	S
Moderate			S	S
Heavy				NS
June Grass				
Slight	NS	NS	NS	S
Light		NS	NS	S
Moderate			S	S
Heavy				NS
Western Porcupine Grass				
Slight	NS	NS	NS	S
Light		NS	S	S
Moderate			NS	S
Heavy				NS
Smooth Aster				
Slight	NS	NS	NS	S
Light		NS	NS	S
Moderate			NS	S
Heavy				S
American Vetch				
Slight	NS	NS	NS	S
Light		S	S	NS
Moderate			NS	S
Heavy				S

NS — Not significant $P > 0.05$.
S — Significant $P < 0.05$.

eliminated vegetation cover (Blood 1966a). Revegetation proceeded quickly once grazing was terminated (Trottier 1974 *unpublished*; see above); however, the resulting cover was a near monoculture of either Kentucky Bluegrass, Smooth Brome (*Bromus inermis*), Western Wheat Grass (*Agropyron smithii*), or Willow-leaved Dock (*Rumex mexicanus*), depending on the site.

There were few significant cover differences recorded for forb species between grazing classes. American Vetch (*Vicia americana*) had significantly greater cover in moderately and heavily grazed stands (Tables 1, 2). Smooth Aster (*Aster laevis*) was significantly reduced under severe grazing. Yarrow (*Achillea millefolium*) and Northern Bedstraw (*Galium boreale*) persisted under all grazing conditions (Table 1).

Weedy forbs which appeared to have invaded heavily grazed stands included Shepherd's Purse (*Capsella bursa-pastoris*), Lamb's Quarters (*Chenopodium album*), Flixweed (*Descurainia sophia*), Dandelion (*Taraxacum officinale*), Stinkweed (*Thlaspi arvense*), White Clover (*Trifolium repens*), and Stinging Nettle (*Urtica dioica*). Dandelion was apparently much more prevalent on overgrazed range during the grazing era than in 1973 based on Blood's (1966a) description and its low occurrence in 1973.

At the time of sampling in 1973, range condition had recovered considerably in terms of standing crop of vegetation and ground cover (Trottier 1974 *unpublished*; see above). However, the low species diversity and poor representation of Rough Fescue in heavily and severely grazed stands, compared with ungrazed stands, indicated that total recovery was far from complete.

Discussion

Heavy livestock grazing during spring and summer resulted in retrogressive changes in the species composition of Rough Fescue grasslands in Riding Mountain National Park. Two assumptions were essential to this interpretation of the vegetation analysis conducted in grazed and ungrazed stands. First, the sample stands which contained little or no Rough Fescue were at one time Rough Fescue grassland because they are physiographically similar to, and merge gradually with adjacent areas grazed to a lesser extent or not at all, and dominated by Rough Fescue (Blood 1966b: 28). Secondly, annual stocking rates and subsequent uneven distribution of grazing were relatively constant, at least during the last three decades of livestock grazing which ended in the late 1960s.

Lightly grazed stands had the greatest plant foliage cover and species diversity. Other studies documenting the impact of light grazing on Rough Fescue grassland of western Canada compared with ungrazed stands describe similar responses (Moss and Campbell 1947; Johnston 1961, 1962; Johnston et al. 1971; Looman 1969). The natural mulch buildup in ungrazed stands tends to favour Rough Fescue, a bunch-forming species (Johnston 1961), but such accumulations limit growth of forbs and eventually grasses as soil temperatures are depressed (Weaver and Rowland 1952; Hopkins 1954; Johnston et al. 1971). Light grazing of Rough Fescue grasslands has been recommended as a means of increasing range

productivity and maximizing red meat production (Johnston 1961, 1962; Looman 1969; Lodge et al. 1971).

Heavy-to-severe spring and summer grazing resulted in pronounced disruption of the native species composition of Rough Fescue grassland. Species diversity was reduced and Rough Fescue was eliminated from most stands, to be replaced by a thick sward of Kentucky Bluegrass and a few weedy forbs. The tendency of Kentucky Bluegrass to increase and dominate overgrazed Rough Fescue grassland was reported by Looman (1969). Jackson (1924) referred to the ability of Kentucky Bluegrass to form pure stands under heavy grazing pressure and warned that it would become the dominant vegetation in the Red River Valley, replacing the native Tall Grass Prairie. The problem of Kentucky Bluegrass out-competing native grasses is also common on overgrazed grasslands of the American midwest (Curtis and Partch 1948; Robacker and Miller 1955; Ehrenreich 1959; Old 1969; Anderson 1972).

Reasons for the competitive advantage of Kentucky Bluegrass over Rough Fescue and associated native grasses on heavily grazed ranges are not clear, although phenological and anatomical adaptations are likely important. Kentucky Bluegrass initiates spring growth in early April before other grasses, grows late into October after other grasses have ceased growth, and effectively spreads by rhizomatous growth, bypassing seed production entirely. Furthermore, the growing points of vegetative stems are below the soil surface throughout the growing season (Evans 1949; Branson 1953; Old 1969; Anderson 1972).

Rough Fescue begins spring growth from mid-April to early May and sometimes initiates regrowth in the fall, but in contrast to Kentucky Bluegrass, the growing points of Rough Fescue vegetative stems are progressively elevated above the root-stem transition during the growing season (Johnston and MacDonald 1967; Stout et al. 1981). Branson (1953) contends that if growing points or seed-bearing stalks are grazed, photosynthetic material may not be replaced. Therefore, the factors affecting resistance to grazing are rhizomatous reproduction, location of the growing points, and the ratio of fertile to vegetative stems. Kentucky Bluegrass has a lower ratio of fertile to vegetative stems (Branson 1953) than Rough Fescue (Johnston and MacDonald 1967).

Rough Fescue reaches full seed-head development between late May and mid-June depending on environmental conditions (Johnston and MacDonald 1967; Stout et al. 1981) and by the third week of June in Riding Mountain. Other prominent associates including Western Porcupine Grass, Richardson's Needle Grass (*Stipa richardsonii*), June Grass, Slender Wheat Grass, Intermediate Oat Grass (*Danthonia intermedia*), and Hooker's Oat Grass (*Helictotrichon hookeri*) flower later in the growing season than Rough Fescue and should also be vulnerable to summer grazing. However, Slender Wheat Grass was not reduced even on heavily grazed stands in this study, and June Grass was not significantly reduced unless annual herbage removal exceeded 50%. June Grass has wide ecological magnitude and is also a component of the drier Mixed Prairie association. Turning out cattle onto the Riding Mountain ranges on or before 1 June coincided with the important growth and reproductive stages of several native species but not those of Kentucky Bluegrass, which was likely phenologically more advanced.

Removal of half or more of grass foliage during the growing season causes root growth to temporarily stop after each removal. Removal in excess of 50% causes complete and prolonged root-growth stoppage and subsequent shoot development is poor (Crider 1955). Heavy clipping or grazing of Rough Fescue severely lessened rooting depth and root biomass (Johnston 1961), and led to changes in soil color, reduced soil organic matter content and lowered soil moisture content (Johnston 1962; Johnston et al. 1971).

The Rough Fescue grasslands appear to have evolved under a grazing regime other than heavy summer grazing and probably should not be intensively used for that purpose. This is in contrast to the Mixed or Shortgrass Prairie association of the Great Plains that has developed in the rain shadow of the Rocky Mountains and is well adapted to summer grazing (Launchbaugh 1972) and is difficult to damage permanently by heavy grazing (Heady 1975).

The northern distribution of Rough Fescue grassland is such that Plains Bison (*Bison bison*) and Elk grazed it during late summer, fall and winter after migrating from the nearby open plains in search of winter refuge. The narratives of Thomison (Warkentin and Ruggles 1970) and Hind (1971) describe winter use of the northern and Parkland grasslands of Manitoba and eastern Saskatchewan by Bison and the annual Bison migration southward to the plains in summer. Furthermore, on the east slopes of the Alberta Rockies at Waterton Lakes National Park and the Ya-Ha-Tinda Ranch (administered by Parks Canada for wintering National Park Service horses) where annual heavy winter grazing by Elk and horses has been monitored for many years, the Rough Fescue community has been maintained in good condition with no loss of native grasses or invasion of undesirable species (J. R. McGillis. 1977. Range

management of the Ya-Ha-Tinda Ranch. Unpublished Canadian Wildlife Service Report, Edmonton. 75 pp.; G. C. Trottier. 1977. Vegetation change in response to protection from grazing in the Fescue grassland of Waterton Lakes National Park. Unpublished Canadian Wildlife Service Report, Edmonton. 54 pp.).

Moss and Campbell (1947) argued not only that the Rough Fescue association was the climax grassland for the Black Soil Region, but also that because Bison did not range northward in large numbers as far as the main Rough Fescue ranges, this climax was maintained during the time when Bison were dominant members of the Great Plains ecosystem. When the main Bison herds did move north it was not during the growing season. This would serve to counter the often stated argument that the pristine stands of Rough Fescue that are protected from summer grazing in Canada's national parks are simply artefacts that could not be representative of conditions as they existed when Bison and other large grazers were most plentiful. Given that Rough Fescue and its associated grasses are vulnerable to summer grazing and once eliminated by overgrazing do not re-establish, it would be difficult to account for the present distribution of Rough Fescue grasslands had Bison extensively depleted Rough Fescue and held the entire range in a disclimax situation over a long period of time.

Where the native Rough Fescue sward has been destroyed by livestock grazing, recovery does not appear possible without rehabilitative management. Examination in 1980 of several of the sample stands studied in 1973 (G. C. Trottier, unpublished data) revealed no apparent invasion of the Kentucky Bluegrass sward by native grasses after 11 years of protection from grazing. Best recovery of overgrazed Rough Fescue range in British Columbia was observed during the second decade of protection from grazing, although a competing sward of Kentucky Bluegrass was not present and Rough Fescue had not been extirpated (McLean and Tisdale 1971).

One potential rehabilitative method for the Riding Mountain ranges is prescribed burning. Early spring burning has been successfully used to reduce Kentucky Bluegrass, freeing the residual native grasses from overbearing competition (Curtis and Partch 1948; Robacker and Miller 1955; Ehrenreich 1959; Tester 1965; Old 1969; Anderson 1972). Preliminary results of repeated spring and fall burning in Rough Fescue grasslands in Prince Albert National Park showed significant reductions in cover and frequency of Kentucky Bluegrass (G. C. Trottier, unpublished data). Prescribed burning followed by reseeding native species, if necessary, should be considered in the disturbed Riding Mountain grasslands.

There appears to be no ecological rationale for allowing livestock grazing in the Rough Fescue grasslands that are protected in national parks. If Parks Canada is to achieve its stated objective of resource management which maintains natural processes and ecosystem conditions (Anonymous. 1979: 41), then requests for livestock grazing must be rejected on the basis of data showing that intensive summer grazing is potentially detrimental to this type of grassland, and that winter grazing might well be in competition with native ungulates.

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Bryophytes of the Cape Parry and Bathurst Inlet Region, Northwest Territories

WILLIAM C. STEERE[1] and GEORGE W. SCOTTER[2]

[1]New York Botanical Garden, Bronx, New York 10458
[2]Canadian Wildlife Service, 4999 — 98 Avenue, Edmonton, Alberta T6B 2X3

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Reported from the Cape Parry and Bathurst Inlet regions in the central northern continental arctic of North America are 42 hepatic and 158 moss taxa.

Key Words: Bryophytes, Cape Parry, Bathurst Inlet, Northwest Territories.

The Cape Parry and Bathurst Inlet regions, located in the central northern edge of the continental arctic portion of North America, are important in providing information on the distribution of the American arctic bryophytes, such as whether or not the ranges extend that far from the eastern Arctic or represent easterly ranges of the Beringian (western arctic) elements in the flora. The comparative inaccessibility of these regions has left their cryptogamic flora largely unstudied until now. The nearest bryophyte studies are those to the west at the Reindeer Preserve (Holmen and Scotter 1971), to the south in the Great Bear Lake and Coppermine regions (Steere 1977a) and to the southeast in the Keewatin District (Scotter 1966; Holmen and Scotter 1967; Zoltai and Johnson 1978). G. W. S. had the opportunity to collect bryophytes as part of a natural resource inventory from the Cape Parry region during 1978 and from the Bathurst Inlet region during 1979.

Cape Parry lies within the northern Interior Plains Province, except for the northeastern corner which is within the Arctic Coastal Plains Province (Bostock 1970). The physiography was described in detail by Mackay (1958a, 1958b, 1963), covering all aspects of physical geography. The physiographic regions were later summarized and renamed by Yorath et al. (1969) to conform with geographic, rather than geomorphic terminology.

The Bathurst Inlet area lies wholly within the physiographic division of the Canadian Shield. Bird and Bird (1961) have described the physiographic regions. The inlet itself and its adjacent lowlands they regard as a long narrow southward extension of the Coronation Gulf lowlands penetrating the Canadian Shield, which forms plateaus to east and west: the Tree River Uplands, Wilberforce Hills and Contwoyto Plateau to the west, and the Bathurst and Buchan uplands to the east.

The Cape Parry region contains elements of polar semi-desert, arctic tundra, tundra-forest transition, and subarctic woodlands. The region lies between the floristically different regions of the upper Mackenzie Valley, where many Beringian species occur, and the central mainland arctic region.

Bathurst Inlet is wholly within the arctic tundra region. The southern portion of the Inlet region has a luxuriant lowland vegetation. Shrub growth of birch and willows in the river valleys reaches two to three meters in height. To the north along the inlet are dwarf shrub heath, damp tundra of sedge and cottongrass, and dry heath tundra. Much of the upland is rock desert with scattered cushion plants, prostrate shrubs, lichens and bryophytes.

The climate of both regions is characterized by long cold winters, short cool summers, and relatively low precipitation.

The numbers in the list of species refer to the following localities.

Cape Parry (CP)

1. Polar semi-desert communities, and seepage areas near Cape Parry, 0-75 m elevation, 70° 10′N, 124° 40′W.
3. *Salix–Carex* tundra near Paulatuk, 0-10 m elevation, 69° 21′N, 124° 07′W.
4. *Salix*-grass, *Carex*–moss, and dwarf heath communities, near pingo, 15-35 m elevation, 69° 20′N, 124° 55′W.
5. *Dryas–Carex* community, near the Hornaday River, 250 m elevation, 69° 05′N, 123° 07′W.
6. Plant communities, near La Ronciere Falls, Hornaday River, 215-275 m elevation, 69° 07′N, 122° 51′W.
8. Lichen–heath and *Picea glauca*–lichen communities, 355 m elevation, 67° 38′N, 123° 27′W.
9. *Picea glauca*–lichen and *Dryas* communities, 410 m elevation, 67° 29′N, 122° 37′W.

10. *Carex–Dryas* tundra near Langton Bay, 3 m elevation, 69°23′N, 125°18′W.
11. *Picea glauca–Ledum* and limestone cliff communities, near the Horton River, 105-200 m elevation, 68°49′N, 124°25′W.
12. *Picea glauca*-lichen community near the Anderson River, 230 m elevation, 68°06′N, 125°24′W.
13. Deflated sandplain with *Picea glauca, P. mariana*-lichen and *Carex* communities, 170 m elevation, 68°28′N, 126°07′W.
14. *Dryas* tundra polygonal community, 275 m elevation, 69°20′N, 125°54′W.
17. Grass-lupine tundra on colluvial slopes, 3-15 m elevation, 70°05′N, 127°12′W.
20. Dissected shale bedrock, 150 m elevation, 69°17′N, 128°17′W.
21. *Salix–Dryas* and *Carex–Salix* communities, on rolling morainic uplands and low-center polygons, 6-9 m elevation, 70°09′N, 127°58′W.
23. *Dryas–Carex* on dissected till uplands, 0-35 m elevation, 70°08′N, 127°29′W.

Bathurst Inlet (BI)

1. Rock lichen, *Ledum*-moss, *Alnus–Carex* communities, near Bathurst Inlet Lodge, 0-335 m elevation, 66°51′N, 108°02′W.
2. Heath-lichen community, near Wilberforce Falls, 130-145 m elevation, 67°05′N, 108°47′W.
3. *Carex–Eriophorum* community, 9 m elevation, 66°58′N, 108°24′W.
4. Heath and *Carex* communities, 60 m elevation, 67°05′N, 108°17′W.
7. Near Twin Caves, Stockport Island, 0-15 m elevation, 67°45′N, 108°59′W.
8. *Dryas*-heath community type, near Baillie Bay, 0-4 m elevation, 67°22′N, 108°51′W.
9. *Dryas, Carex, Salix–Betula* communities, near James River, 30-40 m elevation, 67°15′N, 108°54′W.
10. Rock lichen, *Carex* communities, 175 m elevation, 67°09′N, 107°31′W.
11. *Salix–Carex* and *Betula–Salix* communities, near Fowler Bay, 0-30 m elevation, 67°16′N, 107°32′W.
12. *Dryas–Potentilla* community, 50-75 m elevation, 67°29′N, 107°34′W.
14. *Dryas*-heath and *Dryas–Carex* communities, near Buchan Bay, 0-15 m elevation, 67°52′N, 107°50′W.
15. *Dryas*-heath and *Carex–Eriophorum* communities, 165 m elevation, 67°14′N, 107°15′W.
16. *Dryas*-heath and *Carex* communities, near Hiukitak River, 25 m elevation, 67°09′N, 106°57′W.
17. *Ledum–Empetrum* and lichen–*Ledum* communities, 75-90 m elevation, 66°55′N, 106°45′W.
18. *Ledum–Empetrum* and *Carex–Ledum* communities, 210 m elevation, 66°42′N, 106°40′W.
19. Legume-*Dryas* and lichen-moss communities, near Gordon River, 180-200 m elevation, 66°34′N, 106°41′W.
20. Heath and *Carex–Sphagnum* communities, 240-255 m elevation, 66°09′N, 106°10′W.
21. *Dryas*-legume and *Salix–Betula* communities, near Western River, 60-90 m elevation, 66°06′N, 106°52′W.
22. *Dryas* and *Alnus–Salix* communities, near the delta of Western River, 10 m elevation, 66°22′N, 107°08′W.
23. Rock lichen and *Carex* communities, 150 m elevation, 67°42′N, 107°34′W.
24. Legume–*Dryas* community, 0-8 m elevation, 67°47′N, 107°50′W.
26. *Salix–Dryas*, lichen-moss, and *Carex* communities, near "Window Falls", 90-120 m elevation, 66°38′N, 107°50′W.
27. *Salix–Dryas* community, 40 m elevation, 66°32′N, 107°37′W.
28. *Salix–Dryas* community, near Bathurst Lake, 125-135 m elevation, 66°22′N, 107°24′W.
29. *Carex, Salix–Dryas*, and *Dryas*-legume communities, 190-220 m elevation, 66°08′N, 106°58′W.
30. *Salix–Dryas* community type, 200 m elevation, 66°11′N, 107°21′W.
31. *Dryas* and *Carex–Salix* communities, 210-230 m elevation, 66°22′N, 107°37′W.
32. Lichen–moss community, near Burnside Falls, 50-60 m elevation, 66°52′N, 108°18′W.

Except for the Sphagnaceae which were identified by Dr. Richard E. Andrus, State University of New York at Binghamton, all identifications are by Steere. All specimens are filed at the herbarium of the New York Botanical Garden (NY).

Systematic List of Bryophytes
Hepaticae

A statement of the habitat and arctic American distribution has been made by Steere and Inoue (1978) for each of the species of Hepaticae listed here.

Blepharostoma trichophyllum (L.) Dum. CP 6; BI 1, 2, 26.
Ptilidium ciliare (L.) Hampe BI 10, 15.
Anthelia juratzkana (Limpr.) Trev. BI 2.
Cephalozia pleniceps (Aust.) Lindb. CP 8, 21; BI 2, 10, 16.
Cladopodiella francisci (Hook.) Joerg. CP 1.
Odontoschisma macounii (Aust.) Underw. BI 1, 2, 22, 26.

Cephaloziella arctica Bryhn & Douin BI 1, 2, 10.
Chiloscyphus polyanthus (L.) Corda CP 21.
Plagiochila arctica Bryhn & Kaal. CP 6.
Arnellia fennica (Gott.) Lindb. BI 21.
Anastrophyllum cavifolium (Buch & S. Arn.) Lammes BI 2, 11.
A. minutum (Cranz) Schust. CP 8, 12,13, 21; BI 1, 2, 4, 10, 16.
Chandonanthus setiformis (Ehrh.) Lindb. BI 10, 15, 20, 23.
Gymnocolea inflata (Huds.) Dum BI 1.
Lophozia alpestris (Schleich. *ex* Web.) Evans CP 8; BI 7.
L. atlantica (Kaal.) Schiffn. BI 28.
L. binsteadii (Kaal.) Evans CP 8.
L. collaris (Nees) Dum. CP 6; BI 26.
L. gillmanii (Aust.) Schust. BI 1, 26, 31.
L. heterocolpos (Thed.) M.A. Howe CP 21.
L. incisa (Schrad.) Dum. CP 21.
L. longiflora (Nees) Schiffn. BI 1.
L. ventricosa (Dicks.) Dum. CP 17,21; BI 4, 7, 16, 17.
Mylia anomala (Hook.) S.F. Gray CP 8, 13.
Tritomaria exsectiformis (Breidl.) Loeske. BI 26.
T. quinquedentata (Huds.) Buch BI 1, 2, 26, 31.
Gymnomitrion concinnatum (Lightf.) Corda BI 1, 2.
G. corallioides Nees BI 1, 19.
Diplophyllum taxifolium (Wahlenb.) Dum. CP 3.
Scapania degenii Schiffn. *ex* K. Müll. BI 17.
S. hyperborea Jørg. BI 1.
S. simmonsii Bryhn & Kaal. BI 2.
S. spitzbergensis (Lindb.). K. Müll. BI 15.
Radula prolifera Arnell BI 2.
Frullania tamarisci (L.) Dum. subsp. *nisquallensis* (Sull.) Hatt. BI 2.

Scapania degenii, S. hyperborea, S. simmonsii, S. spitzbergensis, Radula prolifera and *Frullania tamarisci* subsp. *nisquallensis* are all members of a phytogeographically significant and interesting circumpolar element (Steere 1953a, 1976).

Pellia epiphylla (L.) Corda CP 21.
Aneura pinguis (L.) Dum. CP 4, 21.
Athalamia hyalina (Sommerf.) Hatt. BI 1.
Sauteria alpina (Nees) Nees CP 6.
Marchantia polymorpha L. CP 1; BI 1, 2.
Preissia quadrata (Scop.) Nees BI 21.

Musci

An excellent treatment of the North American species of *Sphagnum* has recently been published by Crum (1984); it is particularly notable for its discussions of ecology and distribution, as well as for its illustrations. The habitat and arctic American distribution for most if not all the species of Musci listed here have been given by Steere (1978), who included distribution maps for species of special phytogeographical significance.

Sphagnum angustifolium (C. Jens. *ex* Russ.) C. Jens. CP 8, 13.
S. aongstroemii Hartm. BI 16, 20.
S. balticum (Russ.) Russ *ex* C. Jens. CP 8; BI 2, 4, 10, 17, 18.
S. fimbriatum Wils. CP 8, 21; BI 1, 2, 8, 10, 12, 17, 18, 20, 32.
S. fuscum (Schimp.) Klinggr. CP 8, 13; BI 2, 10, 17.
S. imbricatum Hornsch. *ex* Russ. BI 1, 17, 19.
S. lenense H. Lindb. *ex* Pohle BI 2, 4, 10, 18.
S. lindbergii Schimp. *ex* Lindb. CP 13.
S. nemoreum Scop. CP 8; BI 1, 9, 10.
S. orientale Sav.-Ljub. BI 17.
S. rubellum Wils. BI 2, 4, 10.
S. squarrosum Crome CP 21; BI 1, 2, 9, 10, 11, 14, 16.
S. teres (Schimp.) Ångstr. *ex* C. Hartm. CP 8; BI 2, 9, 17.
S. warnstorfii Russ. CP 8; BI 9.
Andreaea rupestris Hedw. BI 1, 2, 7, 10, 19, 20.
Fissidens osmundoides Hedw. CP 8.
Ceratodon purpureus (Hedw.) Brid. CP 1, 3, 4, 8, 12, 14, 21; BI 1,16.
Distichium capillaceum (Hedw.) B.S.G. CP 1, 4, 6, 11, 17, 21, 23; BI 1, 2, 7, 21, 22, 26.
D. inclinatum (Hedw.) B.S.G. CP 4; BI 26.
Ditrichum flexicaule (Schwaegr.) Hampe CP 1, 3, 4, 6, 8, 17, 21; BI 2, 7, 8, 18, 21, 26, 28, 31.
Saelania glaucescens (Hedw.) Bomanss. & Broth. BI 2, 26.
Seligeria polaris Berggr. CP 6.
Cynodontium polycarpum (Hedw.) Schimp. BI 1, 2, 26.
C. strumiferum (Hedw.) Lindb. BI 17.
Dichodontium pellucidum (Hedw.) Schimp. BI 14, 26.
Dicranum angustum Lindb. CP 8; BI 1, 15, 16.
D. elongatum Schleich. *ex* Schwaegr. CP 8, 12, 13, 21, 23; BI 1, 3, 4, 10.
D. fuscescens Turn. CP 8, 9, 17; BI 1, 31.
D. majus Smith CP 4.
D. scoparium Hedw. BI 3.
Oncophorus wahlenbergii Brid. CP 6, 13; BI 2, 10, 14, 22, 26, 29.
Bryobrittonia longipes (Mitt.) Horton BI 26.

The systematic position of *Bryobrittonia longipes* (as *B. pellucida* R. S. Williams) in the Encalyptaceae was clarified by Steere (1953b) and its geographic distribution updated by Steere (1978); it had hitherto been placed in the Pottiaceae.

Encalypta alpina Smith CP 1; BI 2, 26.
E. longicolla Bruch CP 6.
E. procera Bruch BI 4, 31.
E. rhaptocarpa Schwaegr. BI 1, 15.
Barbula icmadophila Schimp. *ex* C. Müll. CP 1.
Bryoerythrophyllum recurvirostrum (Hedw.) Chen

CP 1, 21; BI 1, 2.

Didymodon asperifolius (Mitt.) Crum, Steere, & Anders. CP 1, 6.

Gymnostomum recurvirostrum Hedw. CP 1, 6; BI 7.

Oxystegus tenuirostris (Hook. & Tayl.) A.J.E. Smith BI 2.

Pottia obtusifolia (R. Br.) C. Müll. CP 1.

Tortella arctica (Arnell) Crundw. & Nyholm CP 1, 5, 6; BI 2, 26.

T. fragilis (Drumm.) Limpr. CP 1; BI 2.

T. tortuosa (Hedw.) Limpr. CP 6.

Tortula ruralis (Hedw.) Gaertn., Meyer, & Scherb. CP 1, 4; BI 4, 7, 26, 28.

Grimmia affinis Hoppe & Hornsch. *ex* Hornsch. BI 2, 10, 14, 19.

G. incurva Schwaegr. BI 31.

G. torquata Hornsch. *ex* Grev. BI 2, 14.

Racomitrium canescens (Hedw.) Brid. BI 1, 11.

R. lanuginosum (Hedw.) Brid. CP 5, 20; BI 1, 2, 4, 10, 15, 24.

Schistidium alpicola (Hedw.) Limpr. CP 6.

S. apocarpum (Hedw.) B.S.G. CP 1; BI 1, 19.

S. gracile (Röhl.) Limpr. CP 6; BI 7, 10, 14.

S. holmenianum Steere & Brassard CP 1, 5.

Although not common, *Schistidium holmenianum* has a very wide distribution in northernmost North America, from western Alaska to Greenland (Steere and Brassard 1976).

S. tenerum (Zett.) Nyh. CP 11; BI 2, 26.

Funaria groutiana Fife CP 3.

F. hygrometrica Hedw. BI 1.

Aplodon wormskjoldii (Hornem.) R. Br. CP 1, 3; BI 4, 9.

The distribution of *Aplodon* was discussed and mapped by Steere (1973).

Splachnum vasculosum Hedw. CP 1.

Tayloria acuminata Hornsch. BI 7.

Tetraplodon mnioides (Hedw.) B.S.G. CP 1,3, 14, 23; BI 1, 4, 28.

T. paradoxus (R. Br.) Hag. CP 8, 14, 21; BI 1, 3, 24.

Maps of the geographical distribution of *Tetraplodon mnioides* and *T. paradoxus* in arctic North America were published by Steere (1977b). The Bathurst Inlet collections of *T. paradoxus* are the easternmost stations yet discovered in Canada; the type locality is between Great Bear Lake and the Arctic Ocean.

Voitia hyperborea Grev. & Arnott CP 5, 14.

Voitia hyperborea is a typically high-arctic circumpolar species, originally described from Melville Island. Its North American occurrence was outlined and mapped by Steere (1974).

Bryum acutiforme Limpr. *ex* Hag. CP 1.

B. algovicum Sendt. *ex* C. Müll CP 1, 5.

B. calophyllum R. Br. CP 1.

B. creberrimum Tayl. CP 1, 4, 5, 12.

B. nitidulum Lindb. CP 1.

B. pallescens Schleich. *ex* Schwaegr. CP 8.

B. stenotrichum C. Müll. (*B. inclinatum* (Brid.) Bland) CP 1, 3, 8, 21, 23.

B. weigelii Spreng. BI 21, 30.

B. wrightii Sull. & Lesq. CP 1, 3.

Steere and Murray (1974) discussed in some detail the geographic distribution of *Bryum wrightii* in North America (it was originally described from easternmost Siberia) and published a map of it. They also discussed its distinctive characteristics as seen in the field.

Leptobryum pyriforme (Hedw.) Wils. CP 1, 3, 17; BI 1.

Pohlia cruda (Hedw.) Lindb. CP 1; BI 1, 2, 7, 26.

P. nutans (Hedw.) Lindb. CP 4, 8, 9, 17, 21; BI 1, 2, 3, 7, 16, 28.

Cinclidium arcticum (B.S.G.) Schimp. CP 6; BI 26, 29.

C. latifolium Lindb. CP 21.

C. stygium Sw. CP 1, 21; BI 2, 9, 21, 26, 31.

Mogensen (1973) published excellent maps of the geographical distribution, worldwide, of the four species of *Cinclidium* in his revision of this genus.

Cyrtomnium hymenophylloides (Hüb.) Kop. (*Mnium hymenophylloides* Hüb.) CP 3, 6; BI 21, 26.

C. hymenophyllum (B.S.G.) Holmen (*Mnium hymenophyllum* B.S.G.) CP 6; BI 2, 26, 30, 31.

Mnium andrewsianum Steere BI 2, 7.

Mnium andrewsianum was first recognized as a distinct species in the field at Great Bear Lake and at Coppermine (Steere 1958, 1977a). Since then, it has been found to have a very wide circumpolar arctic and subarctic distribution, which was mapped by Steere (1978).

M. blyttii B.S.G. BI 7.

M. ellipticum Brid. CP 1, 3, 4, 10, 17; BI 1, 3, 7, 26.

M. medium B.S.G. CP 10, 21, 23.

M. thomsonii Schimp. CP 6, 21; BI 7, 26, 29, 31.

Aulacomnium acuminatum (Lindb. & Arnell) Kindb. BI 31.

A. palustre (Hedw.) Schwaegr. CP 4, 8, 17, 21, 23; BI 1, 3, 4, 9, 11, 22.

A. turgidum (Wahlenb.) Schwaegr. CP 5, 21, 23; BI 1, 2, 12, 16, 17, 19.

Meesia longiseta Hedw. CP 21.

M. triquetra (Richt.) Ångstr. (*M. trifaria* Crum, Steere, & Anderson) CP 10, 21; BI 9, 26.

M. uliginosa Hedw. CP 21; BI 2, 9, 26, 29.

Paludella squarrosa (Hedw.) Brid. BI 2, 9, 32.

Catoscopium nigritum (Hedw.) Brid. CP 1, 3, 9; BI 26.

Bartramia ithyphylla Brid. BI 1, 2.

B. pomiformis Hedw. BI 2.

Conostomum tetragonum (Hedw.) Lindb. BI 10.

Philonotis fontana (Hedw.) Brid. BI 2.

P. tomentella Mol. *in* Lor. CP 1, 21; BI 7.

Plagiopus oederiana (Sw.) Limpr. CP 6; BI 2, 32.

Timmia austriaca Hedw. CP 1, 6; BI 7.
T. bavarica Hessl. CP 1, 6; BI 7.
T. norvegica Zett. CP 1; BI 26.
Amphidium lapponicum (Hedw.) Schimp. BI 2, 10.
A. mougeotii (B.S.G.) Schimp. BI 2.
Orthotrichum anomalum Hedw. BI 26.
O. speciosum Nees *ex* Sturm. BI 26.
Myurella julacea (Schwaegr.) B.S.G. CP 1, 4, 21; BI 2, 21, 22, 26.
M. tenerrima (Brid.) Lindb. CP 21; BI 2, 29.
Leskeella nervosa (Brid.) Loeske CP 6; BI 7.
Pseudoleskeella tectorum (Funck *ex* Brid.) Kindb. *ex* Broth. CP 1.
Abietinella abietina (Hedw.) Fleisch. BI 26.
Amblystegium varium (Hedw.) Lindb. BI 7.
Calliergon giganteum (Schimp.) Kindb. CP 1.
C. richardsonii (Mitt.) Kindb. *ex* Warnst. CP 1, 4, 21; BI 3, 26, 29.
C. sarmentosum (Wahlenb.) Kindb. BI 1, 20.
C. stramineum (Brid.) Kindb. BI 1, 9.
C. trifarium (Web. & Möhr) Kindb. CP 8.
Campylium polygamum (B.S.G.) C. Jens. CP 1.
C. stellatum (Hedw.) C. Jens. CP 1, 4, 6, 8, 12, 21, 23; BI 1, 2, 3, 11, 26.
Cratoneuron arcticum Steere CP 1.
C. filicinum (Hedw.) Spruce BI 9.
Drepanocladus badius (C.J. Hartm.) Roth CP 8; BI 20.
D. brevifolius (Lindb.) Warnst. CP 1, 3, 21.
D. exannulatus (B.S.G.) Warnst. BI 10, 17, 18.
D. revolvens (Sw.) Warnst. CP 1, 3, 4, 6, 8, 14, 21; BI 1, 2, 3, 9, 10, 20, 21, 26, 29.
D. uncinatus (Hedw.) Warnst. CP 4, 21, 23; BI 1, 2, 20, 26, 31.
Hygrohypnum alpestre (Hedw.) Loeske BI 26.
H. luridum (Hedw.) Jenn. CP 6.
Platydictya jungermannioides (Brid.) Crum CP 1, 4; BI 7.
Scorpidium scorpioides (Hedw.) Limpr. CP 3, 8.
S. turgescens (T. Jens.) Loeske CP 1, 3, 5, 6, 8.
Brachythecium groenlandicum (C. Jens.) Schljak. CP 10.
B. salebrosum (Web. & Möhr) B.S.G. CP 3, 6, 10, 23.
B. turgidum (C.J. Hartm.) Kindb. CP 1, 3, 4; BI 1, 3.
Cirriphyllum cirrosum (Schwaegr. *ex* Schultes) Grout CP 6.
Tomenthypnum nitens (Hedw.) Loeske CP 4, 6, 8, 17, 23; BI 1, 2, 3, 9, 21, 22.
Entodon concinnus (DeNot.) Par. CP 6.

Entodon concinnus has a very wide but spotty geographic distribution in North America; it is known in the northern areas from Alaska and Yukon and from Newfoundland (Steere 1975).

Orthothecium chryseum (Schwaegr. *ex* Schultes) B.S.G. CP 1, 6; BI 2.
O. intricatum (C.J. Hartm.) B.S.G. CP 6.
O. strictum Lor. CP 1, 6; BI 14.
Plagiothecium cavifolium (Brid.) Iwats. BI 2.
P. denticulatum (Hedw.) B.S.G. BI 2.
Hypnum bambergeri Schimp. CP 1, 6.
H. callichroum Funck *ex* Brid. CP 23.
H. cupressiforme Hedw. CP 1; BI 2.
H. lindbergii Mitt. CP 17, 21.
H. procerrimum Mol. CP 1, 6.
H. revolutum (Mitt.) Lindb. CP 1.
Isopterygium pulchellum (Hedw.) Jaeg. & Sauerb. CP 23; BI 2, 26.
Hylocomium splendens (Hedw.) B.S.G. CP 8; BI 2, 21, 22.
Polytrichastrum alpinum (Hedw.) G.L. Smith CP 1, 17; BI 1, 2, 16, 17.
P. longisetum (Brid.) G.L. Smith CP 8.
Polytrichum commune Hedw. BI 1,11, 17, 18.
P. juniperinum Hedw. CP 17; BI 1, 16, 28.
P. piliferum Hedw. BI 1, 10, 11, 17.
P. strictum Brid. (*P. affine* Funck) CP 8, 13; BI 2, 3,9, 10, 11, 27.
Psilopilum cavifolium (Wils.) Hag. BI 16.

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The Vascular Plants in Snow Dump Habitats in Ottawa, Ontario.

ILONA ZGIERSKA

1973 Clairvaux Road, Gloucester, Ontario K1C 4K5

Zgierska, Ilona. 1986. The vascular plants in snow dump habitats in Ottawa, Ontario. Canadian Field-Naturalist 100(4): 502–505.

A phytosociological study of snow dumps in Ottawa, Ontario is presented. Forty-eight species are reported for 20 sites. The average number of species found is 13 with a range from 5 to 31. Two thirds of the species found are adventive, naturalized or have escaped from cultivation. Almost half of all species are either halophytes or salt-tolerant.

Key Words: Ruderal plants, snow dumps, synantropic associations, Ontario.

Plant associations resulting from human activities (synantropic associations) that largely comprise introduced species are relatively poorly documented in Canada in comparison with natural plant associations composed of native species. Synantropic associations occur in sites where native flora has been destroyed by deposition of waste products, accumulation of toxic substances, application of herbicides, construction of roads, etc. (cf. Frankel 1970). These sites are invaded by ruderal plants which are adapted to extreme conditions, including a deficit of water and nutrients, and a high level of certain toxic chemicals and ions, and to strong exposure to sunlight. Many species are recent invaders. These newcomers face obstacles in natural habitats due to the competition from the native flora that forms natural associations. It is therefore easier for them to encroach on most of the open places created by man. Synantropic plant associations are apparent in Ottawa on snow dumps, roadsides, vacant lots, and areas that are heavily trampled. These associations are characterized by their sensitivity to soil properties and thus, even on small areas, one can encounter substantial differences between associations (Weber 1961). Left without any human influence they gradually disappear, yielding to more permanent plant associations. In spite of their instability, the synantropic associations have some characteristic species that dominate and exist for as long as a specific human influence prevails. It is thus possible to give them the rank of association.

In the present note I give a detailed phytosociological study of snow dump habitats in Ottawa. Although the occurrence of plants in man-created salty habitats in Ontario has been discussed (Catling and McKay 1975, 1980, 1981), phytosociological analyses have not yet been reported.

Methods

Observations of synantropic vegetation in snow dumps include phytosociological analyses of 20 sites. The locations of these sites are given in Table 1. Table 2 lists all the species found on the study sites. The plant names are taken from Scoggan (1978-1979), except in a few cases where more accurate nomenclature is available. Voucher specimens are placed in the Vascular Plant Herbarium, Agriculture Canada, Ottawa (DAO). At each site all species were recorded and assigned a quantitative cover value (the number before the decimal point) and a sociability value (the number after the decimal point). The cover was estimated as an average taken from a few study plots 10 m^2. Species occuring rarely with a very low cover and sociability were recorded with a "+". The six-point scale of quantitative cover is taken from Braun-Blanquet (1921). The numbers in this scale indicate what percentage of the studied area is covered by a given species: (5: 75-100%); (4: 50-75%); (3: 25-50%); (2: 5-25%); (1: 1-5%); (+: $<$ 1%). The number indicating sociability increases with a growing tendency of a given species to form patches and colonies. Thus 1 indicates that individual plants of a given species grow separately, 2 indicates that they grow in small groups, 3 in larger patches, etc. In order to reflect the significance of salt (NaCl) tolerance, the plants were divided into 3 groups: halophytes, salt-tolerant species, and others, according to Catling and McKay (1980). Also for each species the number of sites occupied was calculated and a class of phytosociological constancy (Braun-Blanquet 1921, 1964) was assigned, depending upon the percentage-frequency of occurrence: V (80-100%); IV (60-80%); III (40-60%), II (20-40%), I (0-20%). Finally the number of species at each site was calculated.

Results and Discussion

Forty-eight species were identified on the 20 sites. The number of species per site varied greatly from 5 to 31, with an average of 13 species. Only three sites supported more than 16 species. The species are divided in Table 2 according to their salt tolerances

TABLE 1. The locations of snow dump sites.

Number	Locality	Date
1,2	Snow dump on NRC ground east of Bathgate Drive	18 Aug. 1984
3,4	Snow dump between Queensway and Chapel Street	30 Aug. 1984
5,6	Snow dump behind Sandy Hill Arena	1 Aug. 1984
7,8	Snow dump south of Ogilvie Road at Bathgate Drive	18 July 1984
9	Snow dump east of Cryville Road north of Queensway	1 July 1984
10,11,12	Alta Vista snow dump south of Coventry Road	3 Aug. 1984
13,20	Snow dump between Industrial Street and St. Laurent	7 Sept. 1984
14,15,16	Snow dump west of Albion Road	2 Aug. 1984
17	Snow dump west of Broad Street	5 Sept. 1984
18,19	Snow dump at the corner of Champagne Street and Wellington	6 Sept. 1984

(see Catling and McKay (1975, 1980, 1981) and Reznicek (1980). There are only 13 species that appear repeatedly on at least nine of the studied sites. These are *Polygonum arenastrum* Boreau. (Knotweed), (cf. McNeill 1981); *Puccinellia distans* (L.) Parl (Alkali Grass); *Hordeum jubatum* L. (Fox-tail Barley); *Chenopodium glaucum* L. (Oak-leaved Goosefoot); *Chenopodium album* L. (Lamb's Quarters); *Ambrosia artemisiifolia* L. (Ragweed); *Echinochloa crusgalli* (L.) Beauv. (Barnyard Grass); *Panicum capillare* L. (Old Witch Grass); *Atriplex patula* L. (Spearscale); *Medicago lupulina* L. (Black Medic); *Matricaria matricarioides* (Less.) Porter (Pineapple-Weed); *Plantago major* L. (Common Plantain); and *Taraxacum officinale* Weber (Common Dandelion). Of these, 11 species are either halophytes or salt-tolerant. Only one, *Panicum capillare*, is native; it may, however, be locally adventive. That the frequent appearance of these species leads to the similarities in floral composition of the studied sites is probably related to the fact that these few species are best adapted to quick colonization of the special environment of snow dumps. The most commonly represented species occurring in all studied sites is *Polygonum arenastrum*. Only rarely does it occur in small quantities.

Species associated with *Polygonum arenastrum* include *Puccinellia distans, Plantago major, Matricaria matricarioides, Chenopodium glaucum*, and *Taraxacum officinale*. All these species are known to form well-developed plant associations covering heavily trampled areas (Gutte 1966, 1972). *Puccinellia distans* usually occurs in salty soils or dry places covered with rubble and various debris, and has been frequently described from such situations in Europe where it dominates plant associations (Weber 1961). In the Ottawa area it also appears in wet ditches. The large phytosociological constancy is reached by species such as *Chenopodium album, Echinochloa crusgalli*, and *Ambrosia artemisiifolia*. They occur in almost all studied sites. Together with *Panicum capillare* and *Atriplex patula* they belong to the group of species tolerant to salt. *Ambrosia artemisiifolia* can be found in a wide variety of soils and it is a typical species of after-harvest cover in grainfields and hayfields. It is also common among roadside floras. *Spergularia marina* (L.) Griseb (Sand-Spurey), which forms quite a large aggregation in location #16, is a typical halophytic species. It has been previously reported from salty habitats in southern Ontario where it forms associations with *Puccinellia distans, Atriplex patula* var. *hastata*, and *Aster subulatus* (Catling and McKay 1975, 1980). In the studied snow dump associations, there are also species characteristic of meadow communities. These include *Phleum pratense* L. (Timothy), *Lotus corniculatus* L. (Bird's-foot Trefoil), *Trifolium pratense* L. (Red Clover), and *Trifolium repens* L. (White Clover). However, they occur in small quantities. A well established association dominated by *Xanthium strumarium* L. (Cocklebur) occupies sites on the edges of snow dumps in areas less subject to trampling and vehicle traffic.

The deposition of large masses of snow undoubtedly leads to changes in mineral composition of soil and apparently delays the development of the vegetation cover in the spring. The soil is compacted by vehicle traffic and it contains large quantities of salt, resulting in poor drainage. The salt level probably peaks in late spring just after the snow has melted but may continue to accumulate locally in evaporation "pans". The pH of soil varies from

TABLE 2. Species in snow dump habitats in Ottawa 1984.

Locality	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Phyto-sociological constancy class	Phyto-sociological constancy number
Number of species	15	13	24	14	21	31	8	16	7	13	10	10	12	10	5	8	16	13	14	12	class	number
Halophytic species																						
**Agropyron repens*			+			1.1						+				1.2	+				II	5
**Hordeum jubatum*	+	+	+		+	+			1.1	+	+	2.1	1.2	+							III	11
**Puccinellia distans*	1.1	1.2	+		1.1	+			1.1	1.1	2.1	1.1		+			+		+		IV	12
**Polygonum arenastrum*	3.2	4.2	2.1	3.3	3.2	4.2	2.1	1.1	3.1	4.2	4.3	1.1	3.3	2.1	+	+	2.1	2.2	3.2	4.4	V	20
**Chenopodium glaucum*	2.1	1.1		1.1	1.1	1.1	3.2						+		1.1		1.1				III	9
**Spergularia marina*														+	4.2						I	2
**Aster brachyactis*	+	1.1			+																I	3
**Kochia scoparia*			1.1			+				1.1	+								+		II	5
Salt tolerant species																						
**Digitaria sanguinalis*						+											+			+	I	3
**Echinochloa crus-galli*	1.1	1.1	2.1	2.2	1.2	1.1			2.1	1.1	1.1	1.1	1.1	1.1		1.1	1.1	2.1	1.1	2.2	V	17
Panicum capillare	+	+		+	+	1.1	1.1	+						+		+	1.1	1.1	1.1	1.1	IV	13
**Setaria glauca*			+		+	+							+				1.1	+	+	+	II	8
**Setaria viridis*			+	+	+	+											+	+	+		II	7
Sporobolus neglectus						+															I	1
Sporobolus vaginiflorus			+																		I	1
**Atriplex patula*	1.1	2.2	1.1	+		+				1.1	2.1		3.2	3.3	3.2	2.2				2.2	IV	12
**Chenopodium album*	1.1	+	1.1	1.1	1.1	2.1	1.1	1.1	+	1.1	1.1		+	1.1	+	2.3	4.3	1.1	2.1	+	V	19
**Medicago lupulina*	+	+	+	+		1.1	+	1.2		+		+						+	+		III	11
**Melilotus alba*			+		+	2.2		2.1				+								+	II	6
**Ambrosia artemisiifolia*	+	1.1	2.1	1.1		2.2	+	1.1	2.1	1.1	1.1	3.3	1.1	+	+	+	1.1	1.1		1.1	V	18
**Artemisia biennis*			+		+																I	2
Bidens frondosa						+										+					I	1
**Lactuca scariola*					+	+															I	2
**Matricaria matricarioides*	+		+	+	+	+	1.1	1.2		1.1									+	+	III	10
**Sonchus arvensis*	+							+													I	2
Other species																						
Argostis palustris		+	+					+													I	3
**Eragrostis cilianensis*				+															+		I	2
**Panicum milliaceum*					+	+															I	2
**Phleum pratense*			+		+			+													I	3
Poa pratensis								+													I	1
Cyperus esculentus						+															I	1
**Polygonum convolvulus*																		+			I	1
**Polygonum persicaria*	+		+	+	+	+											+	+			II	7
**Amaranthus graecizans*																			+		I	1
**Amaranthus retroflexus*			+																		I	1
**Erysimum cheiranthoides*						+															I	1
**Lepidium densiflorum*						+															I	1
**Lotus corniculatus*								+													I	1
**Trifolium pratense*					+	+							+				+			+	II	5
**Trifolium repens*						+		+		+		+	+				+				II	6
**Malva neglecta*						+												+	+		I	3
**Plantago major*	+	+	+	+	+	1.2			+	1.2	2.1		1.1				1.1	+	+		IV	13
**Arctium lappa*							+	+													I	2
**Chrysanthemum leucanthemum*								+													I	1
**Conyza canadensis*			+																		I	1
**Lactuca biennis*						+															I	1
**Taraxacum officinale*			+		+	+		+			+		+	+			+			+	III	9
Xanthium strumarium			4.2	2.1	2.1					1.1		4.1						3.2			II	6

*-adventive, naturalized or escaped species from cultivation.

neutral to slightly alkaline. These highly disturbed sites are colonized by pioneer species consisting mainly of therophytes (a plant life-form classification including annual plants that survive a yearly unfavourable season only by seeds). The late germination of seeds may also allow some of these annuals to avoid the period of the highest salt concentration. Most of the species of the snow dump habitat germinate in the middle of summer, grow very fast and complete their development cycle by the end of September. *Aster brachyactis* Blake (Short-rayed Aster) germinates latest of these species and is still developing when many other species have finished.

The plants occupying this type of habitat are well adapted to heavy compaction, periodic drought, and to the excess supply of salt (NaC1). This may be seen in several morphological characteristics of the plants, such as thick succulent leaves, strong ramification of stems and leaves which spread closely to the ground (e.g. spreading habit of *Polygonum arenastrum*) or else have a rosette formation. Individual plants of some of the species are much smaller in snow dumps than the same plants growing in a less demanding environment, and this apparent ability to adjust to environmental resources and/or pressure may also contribute to their success.

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Breeding Bird Communities in a Hardwood Forest Succession in Nova Scotia

K. MORGAN and B. FREEDMAN

Department of Biology and School of Resource and Environmental Studies, Dalhousie University, Halifax, Nova Scotia B3H 4J1

Morgan, K., and B. Freedman. 1986. Breeding bird communities in a hardwood forest succession in Nova Scotia. Canadian Field-Naturalist 100(4): 506–519.

The response of breeding birds to hardwood forest disturbance and regrowth was examined using a chronosequence of 23 stands aged from 1 to 74 years. The avifauna of young, clearcut stands (≤ 12 years old) was distinct in both species and density from mature stands (≥ 20 years old). The most important species of young stands were Chestnut-sided Warbler, Common Yellowthroat, Northern Junco, and White-throated Sparrow, while older stands were dominated by Least Flycatcher, Hermit Thrush, Red-eyed Vireo, Northern Parula, Black-throated Green Warbler, American Redstart, and Ovenbird. As clearcut stands developed and began structurally to resemble a forest, especially with the establishment of a tall, relatively dense shrub canopy, species of birds more typically associated with closed stands began to invade. Bird species density, diversity, and richness levelled off in the transitional stage between recent clearcuts and young forests, and at this stage there was a mixture of open and closed canopy species. With further succession, species typical of young stands were eliminated from the avifauna. The overall effects of timber harvesting upon the avifauna of this hardwood forest were not severe, and were of limited duration.

Key Words: Hardwood forest, chronosequence, clearcutting, bird abundance, diversity, guilds, habitat, Nova Scotia.

The concept that vegetation structure influences the population density and species composition of avian communities is not new (Pitelka 1941). Studies have demonstrated strong relationships between spatial complexity and bird species diversity (MacArthur et al. 1961, 1962; Karr and Roth 1971; Roth 1976), and between habitat structure and bird community composition (Johnston and Odum 1956; James 1971; Shugart et al. 1978; Collins et al. 1982). These observations have led to the hypothesis that it should be possible to determine whether a given habitat is suitable for a particular bird species by examining the three dimensional and compositional character of the vegetation. In addition, it should be possible to manage breeding bird communities by habitat manipulation, for example through forestry (Verner 1975; Noon et al. 1980).

Habitat changes caused by forestry may drastically alter the avifaunal composition of affected sites. The seral communities that follow disturbance of conifer forests have been relatively well examined in North America (e.g. Kilgore 1971; Franzreb 1978; Welsh 1981; James and Wamer 1982). In comparison, northern hardwood forests have been less frequently studied, especially in eastern Canada (Freedman et al. 1981).

In response to the need for information on successional changes occurring in breeding bird communities following the disturbance of hardwood (i.e. angiosperm) forests, the objectives of this study were i) to determine the densities of breeding bird species in a post-disturbance chronosequence of hardwood stands; ii) to analyze at the avian community, guild, and species levels the quantitative response to changes in habitat; iii) to identify statistically the key habitat features apparently selected by birds.

Methods

Field work was conducted within Kings County, Nova Scotia (ca. 44°50′N, 64°44′W). Over three breeding seasons (May-September, 1980-1982), 23 even-aged stands of different post-disturbance ages were surveyed. All stands ≤ 20 years old originated with clearcutting, and older stands originated with wildfire. All sites were within 10 km of each other. The shape and extent of the cutting treatment dictated the sizes and boundaries of the study plots. Consequently, the plot areas (from 5 to 7 ha, except for one 2 ha plot which was a habitat island) were smaller than the 10 ha recommended by the International Bird Census Committee (1970); see also Engstrom and James (1981). All stands were bounded by mature forest.

This northern hardwood forest was fairly uniform, and was dominated by Sugar and Red maple and by Paper and Yellow birch (scientific names of all species are in Appendix 1). American Beech, White Ash, and Red Spruce were also present in the understory and

canopy of some stands, but in low density. Open shrubby stands were dominated by the stump sprouts and seedlings of the dominant tree species and Striped Maple, Pin Cherry, Witherod, Speckled Alder, Hazelnut, and Witch-hazel. The herb–low shrub stratum was dominated by Hay-scented Fern, Wood Fern, Bracken Fern, Wild Sarsaparilla, Bunchberry, Fly Honeysuckle, Bush Honeysuckle, various species of raspberry and blackberry, and various species of Asteraceae.

Bird populations were calculated using the spot-mapping method (Williams 1936; IBCC 1970). Each plot was surveyed 10 times (8 dawn and 2 dusk censuses). Bird species diversity was calculated as $H' = -\Sigma(p_i \cdot \ln p_i)$ (Shannon and Weaver 1949), where p_i is the proportion of the total number of individuals occurring as species $_i$. Density was expressed as the number of territories/10 ha. Diversity and density were calculated using only species with ≥ 0.5 territories per plot. However, richness (i.e. number of species) also included species with < 0.5 territories.

The avifauna was divided into nesting and foraging guilds, following the designations of Noon et al. (1979), Samson (1979), and Sabo and Holmes (1983). The guild categories were i) nesting — ground, cup (non-ground), and hole; and ii) foraging — aerial, flycatcher (and hoverers), ground searcher, nectar feeder, predator (raptors), tree driller, foliage searcher, and trunk gleaner.

The vegetation of each plot was divided into three strata: i) trees were defined as woody plants ≥ 5 cm in dbh (diameter at breast height) and > 1.5 m tall; ii) shrubs were defined as woody plants > 0.5 m tall and < 5 cm in dbh; and iii) ground vegetation included all plants < 0.5 m tall. All trees within random 20 m $\times$ 20 m quadrats were tallied for species, dbh, and height of dominant trees. Within each 20 m $\times$ 20 m quadrat, there were two 5 m $\times$ 5 m quadrats, in which species, diameter at 0.5 m, and height of shrub stems were recorded. To measure cover of ground vegetation, fifty random 1 m $\times$ 1 m quadrats were positioned along transects. Cover of exposed mineral soil, slash, and litter was also estimated. Canopy cover was estimated at each 1 m^2 quadrat, by sighting upward through a paper cylinder (4.2 cm diameter, 10.5 cm length) and estimating the area obscured by foliage. To measure vertical cover, a 4 m pole marked at 0.5 m intervals was placed in each 1 m^2 quadrat. The amount of foliage obscuring each meter interval was assessed while viewing the pole from a constant distance (10 m) and direction. Percent shrub cover was determined as the mean of vertical cover in the height intervals: 1-2 m, 2-3 m, and 3-4 m.

Foliage height diversity was calculated using the Shannon-Weaver Index, where p_i = % canopy cover, % shrub cover, or % herb cover. Percent vertical cover was the sum of percent cover in all four meter intervals, whereas percent vegetation cover was the sum of the canopy, shrub, and herb covers. Percent understory cover was the sum of herb and shrub covers.

The initial stage of data analysis involved testing for inter-relationships using Pearson product-moment correlation coefficients. Vegetation and avian community measurements were tested separately and together. For some analyses, the data set was treated as a whole, or sub-divided into immature (1-12 years) and mature (20-74 years) stands, since these age-classes had distinctive bird communities.

The degree of avian similarity of sites was also tested. Coefficients of species similarity (S_s = Sorensen coefficient) were calculated as follows: $S_s = 2C/(A + B)$, where C = the number of species occurring in both plots, and A and B are the total number of species in each plot (Gillespie and Kendeigh 1982). Coefficients of population similarity (S_p) were calculated as $S_p = 1.0 - \Sigma (p_a - p_b)/(P_a + P_b)$, where p is the population of a species in plot a or b, and P is the combined populations of all species in each plot (Odum 1950). S_s and S_p values were expressed as percentages. Following Bond (1957), the coefficients of species or population similarity were summed (by stand) to calculate a table of similarity indices. This allowed a comparison of the similarity of each stand to all others.

In a third similarity analysis, the population densities of 39 bird species were used in an unweighted pair group cluster analysis, based on the chi-square statistic (Sneath and Sokal 1973; Dixon 1981). Chi-square measures the difference of frequencies and is recommended when the data are counts (Dixon 1981). The resulting cluster diagram is a two-dimensional representation of 23 sites in relation to 39 bird species.

To further explore for possible relationshps between avian and habitat variables, several additional analyses were performed. Stepwise multiple regressions were calculated, with avian community indices (density, diversity, richness) or guild proportions regressed against habitat variables. The data set was treated as a whole, and also subdivided into two age-class subsets.

Finally, we performed a principal components analysis (PCA) of the habitat variables. The resulting multivariate principal components are exact mathematical transformations of the original data, with the new multivariate variables being orthogonal (uncorrelated) to each other, and the eigenvalues maximized (these represent the variance along one principal axis). As successive principal axes are

TABLE 1. Densities (pairs/10 ha) of bird species on the various plots. T = transient (rare on or above plot); V = visitor (common on or above plot); + = < ½ territory/plot. Note: sites 7, 19, and 20 were (1980) re-surveyed as sites 9, 22, and 23 (1981); site 2 (1981) was re-surveyed as site 3 (1982).

	Site: 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Nesting	Foraging
Species	Age: 1	1	2	3	3	3	5	5	6	8	8	12	20	30	40	50	50	60	73	73	73	74	74	guild	guild
Ruffed Grouse	+						+		V	V	V				T	V			+	+				GN	GS
Common Snipe	1		T	1	+																			GN	GS
Common Nighthawk	V							V			V			T										GN	A
Merlin	T	+																						CN	P
Red-tailed Hawk	T														2									CN	P
Ruby-throated Hummingbird			T	2	3	3	2	1	2	2	+	1						T			V			CN	N
Downy Woodpecker		+	T											T					V		V			H	TD
Hairy Woodpecker	T			V	V		V		V	V		T			T		V	T	+	V		+		H	TD
Pileated Woodpecker														T	T		1				V			H	TD
Yellow-bellied Sapsucker			V	+							V			+	2		T				+			H	TD
Common Flicker	V	V	V	+	V	V		1		T	1	V						T						H	GS
Eastern Wood Pewee		V	1	V						+	T	1	+					1	1	V		1	T	CN	F
Least Flycatcher		V	V		V					V	V		21		20	13	8	13	14	29	V	22	18	CN	F
Olive-sided Flycatcher			T	T	V					T	1	T												CN	F
Alder Flycatcher					V	2	3	2	2	5	6													CN	F
Yellow-bellied Flycatcher			T																			+		CN	F
Tree Swallow	T	T	V	1		T		T	2		T							T						H	A
Chimney Swift	T	V									T			3	+		V							H	A
Blue Jay	V	V		V						T	1	1				T		V			T			CN	TFS
Gray Jay										T														CN	TFS
Northern Raven	T	T	T					T									T							CN	P
Black-capped Chickadee		T		+	V	T	V			V	V	+	T			+	T		V					H	TFS
White-breasted Nuthatch													T									V		H	TG
Gray Catbird				+																				CN	TFS
American Robin	1	4	6	1	V		V	T		2	+	1	V	6	4	5	5	T	2	V		1	+	CN	GS
Swainson's Thrush										T	1			2	T		4				V		V	CN	GS
Hermit Thrush	+	2	2	V		2		V	V	2	5	3	6	8	13	7	8	5	5	6	3	4	1	GN	GS
Veery			T	V				2		2	9	3	6	11	6	6	V	6	1	5		3	4	GN	GS
Cedar Waxwing	T	T	V			V			V	V	T	V		T										CN	TFS
Red-eyed Vireo		1	1	V			V			5	6	6	18	12	16	7	19	6	5	8	3	11	13	CN	TFS
Solitary Vireo				2			V							T	4	5	T	2	4	6	V	4		CN	TFS
Northern Parula		V	V	V		2	V			1	1	1	6	6	9	6	4	5	3	2	4	3	2	CN	TFS
Black-throated Green Warbler		1	1					T		V		V	15	8	4	2	6	3	4	2	3	5	8	CN	TFS
Black-throated Blue Warbler						+				1			3	5	2	T	T		V		3	3		CN	TFS
Magnolia Warbler			T	V		+				2	1	V	+	2			3		V					CN	TFS
Yellow-rumped Warbler	T	V		V							T			T		4	T	T	V			2		CN	TFS
Canada Warbler								T			1								V			+		GN	TFS
Chestnut-sided Warbler	1	V	V	10	4	30	19	12	31	32	9	12				T		2			V	+		CN	TFS
Bay-breasted Warbler						V																		CN	TFS
Black-and-white Warbler		1	V	V	V	6	V	1	6	6	4	6	9	2	2	6	6	5	6	2	4	5	2	GN	TG
Blackburnian Warbler						T																		CN	TFS
American Redstart		V	T	V	+	T	V	V	2	6	9	9	15	18	10	11	8	14	8	2	10	18	14	CN	F
Tennessee Warbler																						1		GN	TFS
Nashville Warbler										T								T						GN	TFS
Mourning Warbler			2		+	T	9	2	3	1	1	1										V		GN	TFS
Common Yellowthroat		T	4	2	30	16	13	32	29	32	18	6		T					+		2			GN	TFS

TABLE 1. Densities (pairs/10 ha) of bird species on the various plots *(concluded)*.

Species	Site:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Nesting guild	Foraging guild
	Age:	1	1	2	3	3	3	5	5	6	8	8	12	20	30	40	50	50	60	73	73	73	74	74		
Northern Waterthrush											T									2	V		4		GN	GS
Ovenbird					V				+			T	4	24	23	18	13	15	8	13	15	20	18	13	GN	GS
Rusty Blackbird		V		T		3			T																CN	GS
Northern Junco		3	9	9	5	7	5	3	3	2	1	1	V		V		4	3		2	V	2	1		GN	GS
Red Crossbill									T																CN	TFS
White-winged Crossbill							T																		CN	TFS
Purple Finch			V		V			T	V		V		T			T		T		T		V			CN	TFS
Evening Grosbeak				T							T														CN	TFS
American Goldfinch				T					T	1	T	T			T		T								CN	TFS
Rose-breasted Grosbeak							T	V		V	T		1	V	3	2	1		T	2	2		V	7	CN	TFS
White-throated Sparrow		2	6	8	9	19	13	10	9	9	4	9	2				1			3		V	1		GN	GS
Song Sparrow		6	T		9	7	2		2			1	1												GN	TFS
Total Density		14	24	34	42	73	81	59	67	89	104	85	59	123	109	114	91	90	70	75	79	54	107	82		
Species Diversity		1.51	1.62	1.90	2.02	1.60	1.81	1.68	1.70	1.76	2.08	2.46	2.46	2.14	2.33	2.36	2.53	2.34	2.29	2.36	1.88	1.84	2.42	1.95		
Species Richness (incl. +)		8	9	9	14	10	12	8	12	11	17	21	18	12	15	16	16	13	12	19	12	10	23	11		

generated, the greatest, second greatest, and successively less significant sources of variation are removed. We only subjected the two age-class habitat subsets to PCA. This was done since PCA is inappropriate when there are variables that show little or no variation along a large portion of a continuum (e.g. our tree-related variables) (Pimentel 1979). To explore for statistical relationships between avian variables and the multivariate PCA habitat variables, we correlated bird density, diversity, and richness, and the densities of the most important bird species in each age-class against the PCA axes.

The avian and habitat variables and their code acronyms are listed in Appendix 1.

Results and Discussion

General Patterns in the Avian Community

Breeding bird densities of mature stands ranged from 54 to 123 pairs/10 ha (Table 1). This range of densities is similar to that observed in hardwood forests elsewhere. For example, in a chronosequence of oak forests in Pennsylvania, Probst (1979) reported densities between 16 and 98 pr/10 ha. Other studies have found densities of 71 pr/10 ha in a 34 year old Paper Birch–Red Maple stand in Minnesota (Doran and Todd 1976); 85 pr/10 ha in a 21 year old birch stand in Maine (Townsend 1968); and 79–109 pr/10 ha in the Hubbard Brook hardwood forest in New Hampshire (Holmes and Sturges 1975).

There were marked differences in the species occurring in young and old stands (Table 1). The most characteristic and abundant species of young stands were Common Yellowthroat (averaging 11.4 pr/10 ha for stands ≤ 12 years old), Chestnut-sided Warbler (10.0), White-throated Sparrow (6.3), Northern Junco (3.0), Song Sparrow (2.3), Alder Flycatcher (1.7), and Ruby-throated Hummingbird (1.3). For older stands the most important species were Ovenbird (averaging 16.4 pr/10 ha for stands ≥ 20 years old), Least Flycatcher (14.4), American Redstart (12.2), Red-eyed Vireo (10.7), Hermit Thrush (6.3), Black-throated Green Warbler (5.5), and Northern Parula (4.5). These are similar to the observations of Freedman et al. (1981) for mature stands and 3 to 5 year old clearcuts in the same area.

Following habitat disturbance by clearcutting, densities of breeding birds in the chronosequence increased until 20 years, after which there was a slight but irregular decline in older fire-disturbed stands (Table 1). A tendency for avian populations to peak early in forest succession, followed by a decline, has also been noted by Bond (1957), Karr (1968), Flack (1976), and Probst (1979). Bird species diversity initially increased, reaching an irregular plateau by

the eighth year (Table 1). Declining bird diversity in the later stages of succession has been reported by Johnston and Odum (1956), Ambrose (1975), Roth (1976), McArthur (1980), and others. Species richness increased until the eighth year. After that, the number of species was variable within site age-classes (Table 1). Other studies have reported declines in species richness in older stands (Bond 1957; Karr 1968; McArthur 1980).

Probst (1979) examined the effects of cutting oak forests, and found that vigorous sprout growth promoted a rapid recovery of both plant and bird communities. He predicted that within 6 years of clearcutting the total bird density and diversity would surpass that of mature stands. We found that by the eighth year populations were greater than those of most older stands (> 50 years old), whereas diversity levelled off later (Table 1).

The avifauna of the 23 plots was subdivided into nesting and foraging guilds (Table 2, see Table 1 for designations of species). Hole nesters as well as four foraging guilds (aerial foragers, nectar feeders, tree drillers, and predators) occurred too infrequently to allow investigation of habitat associations. Initially ground nesting dominated, but this was gradually replaced by above-ground cup nesting (Table 2). From 30 years onward, there was roughly a 3 : 2 ratio of cup : ground nesters.

Ground foraging was initially the dominant method of acquiring food (Table 2). However, by the third year rapid herb and shrub growth had reduced the amount of exploitable ground surface, while providing abundant foraging substrate for foliage gleaners. Foliage gleaner dominance was also short-lived, and by ca. 20 years the species were divided rather evenly among ground searchers, foliage gleaners, and flycatchers, with average proportions of 35%, 29%, and 30%, respectively.

Franzreb and Ohmart (1978) and Maurer et al. (1981) also found that ground searchers benefited from habitat disturbance, and that their abundance decreased with secondary succession. However, Probst (1979) found that by the time the canopy of an oak forest had reached 12–15 m, ground foragers were again an important component of the avifauna. In the present study, canopy heights in this range corresponded with ages 20 through 50 years, a period when ground foragers showed renewed importance. Foliage searchers were found by Franzreb and Ohmart (1978) to be adversely affected by logging, due to a reduction in the total biomass of foliage rather than the loss of tree volume or reduced foliage height diversity. With time this guild increased in importance because of the progressive redevelopment of the canopy (DesGranges 1980; May 1982). Both Noon et al. (1979) and Maurer et al. (1981) found that habitat disturbance greatly reduced flycatcher density, a consequence of either insufficient numbers of perches, or unsuitable prey in the open habitats. A similar response was suggested by our study (Table 2). Timber gleaners have also been observed to decline after clearcutting in West Virginia, primarily because of the lack of large trees (Maurer et al. 1981). In the present study, timber gleaners did not show an obvious trend with stand age.

Habitat Changes

Following disturbance, sites in the chronosequence underwent a flush of herbaceous growth, reaching maximum cover by the sixth year (Table 3). This decreased the amount of exposed mineral soil and initiated the development of a litter layer. Concurrent with the growth of herb cover was rapid development of a shrub layer, largely through stump-sprout regeneration of cut trees, but also through seedling establishment. Shrub stem density reached a maximium of 54 000 stems/ha by 6 years, and shrub foliage cover peaked between 8 and 12 years. Height of the shrub layer increased progressively until ca. 20 years. Older stands showed a much reduced influence of shrub-sized vegetation. Canopy height, which took into account any changes of status from shrubs to trees, was fairly constant (15–17 m) by 50 years. Canopy cover peaked by 20 years, remained fairly constant until ca. 50 years, and then declined slightly.

The model of Aber (1979) of succession in a northern hardwood forest showed that a well-developed canopy had formed by 11 years. Similarly, we found that by 12 years a dense canopy had developed. In older stands canopy cover declined slightly, likely because of mortality of intolerant species. As expected, portions of the canopy moved upward along the chronosequence, leading to a more diverse vertical distribution of foliage. However, the effects of shading and other stresses on the lower strata worked against this trend. Foliage height diversity (FHD) peaked by the eighth year and then declined until 50 years. In stands > 50 years old, FHD began to increase once again. Auclair and Goff (1971) reported an increase in FHD during the early stages of succession. They found that FHD increased with stand age in relatively open-canopied stands that occurred on sites with extremes of habitat variables, whereas in less stressful situations the effects of competition on the understory reduced FHD. These authors also suggested that, in the absence of further disturbance, foliage height diversity would eventually decline on all site types, as the tree foliage layer became dominant.

TABLE 2. Proportions of major nesting and foraging guilds, expressed as a percentage of the total bird density on each plot. Some minor guilds are not reported here.

Guild	Site:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
	Age:	1	1	2	3	3	3	5	5	6	8	8	12	20	30	40	50	50	60	73	73	73	74	74
a) Nesting Guilds																								
ground nesters		89	75	73	60	86	54	60	76	55	48	57	45	37	40	34	41	36	35	42	36	56	35	27
cup nesters		11	25	27	37	14	46	40	22	43	52	41	55	63	57	65	59	63	65	58	64	44	65	73
b) Foraging Guilds																								
ground foragers		50	87	73	37	40	25	23	22	13	12	30	21	29	46	37	39	39	28	36	34	47	29	24
foliage gleaners		50	9	24	54	56	62	70	71	72	70	47	51	34	33	33	28	36	27	24	24	25	28	31
flycatchers		0	0	3	0	0	2	5	3	5	10	19	17	29	17	27	26	17	38	31	40	20	39	42
timber gleaners		0	4	0	0	0	7	0	2	6	6	4	10	8	1	1	7	7	7	9	2	8	4	3

Relationships Among Bird Communities

A basic working hypothesis of the chronosequence method is that similar sites in close proximity develop similar plant or animal assemblages at approximately the same rate following disturbance. In addition, these communities usually change in character (i.e., species present and their relative abundances) as succession proceeds. We investigated these problems in several ways. A correlation matrix of densities of 24 bird species among the 23 census plots is presented in Figure 1. Many strong correlations are apparent, but the general observation is that early seral species are associated with other early species, and mature with mature. This coincidence of species density and occurrence suggests the existence of distinctive bird communities in young and mature stands.

This relationship is further illustrated in Figure 2, which is a matrix of bird species similarity coefficients (S_s; an index that examines each site pair combination for presence or absence of species, regardless of population). These data indicate that $> 50\%$ of the maximum coefficients of species similarity occurred between pairs of stands that were most close in age. Two generalizations can be made from Figure 2: i) from ca. the eighth year, avian communities were more similar to each other in species composition than in stands < 8 years old; and ii) stands between 8 and 12 years old had a mix of bird species found in both open and mature stands. McArthur (1980) reported that bird species typical of mature forests were frequently

TABLE 3. Summary of habitat analysis. See Appendix 2 for acronyms.

Site	Age	Area (ha)	PSL (%)	PMS (%)	PLT (%)	PHC (%)	SHD/1000 (stems/ha)	SBA (m^2/ha)	PSC (%)	MSH (m)	TRD/100 (stems/ha)	TBA (m^2/ha)	CAN (%)	CHT (m)	FHD (H′)	PVG (%)
1	1	7.6	16.8	26.1	29.8	40.4	3.8	0.4	2.3	1.7	0.0	0.0	0.0	1.7	0.31	42.7
2	1	5.1	28.7	10.6	70.6	61.9	15.9	1.0	3.3	1.2	0.0	0.0	2.3	1.2	0.31	67.5
3	2	5.1	18.5	10.6	66.3	74.0	24.2	1.2	8.3	1.4	0.0	0.0	2.3	1.2	0.44	84.6
4	3	4.1	15.3	1.0	67.5	79.7	29.4	3.0	5.0	2.2	0.0	0.0	0.0	2.2	0.22	84.7
5	3	3.4	42.1	0.5	38.3	75.1	24.0	2.2	32.0	2.3	0.0	0.0	0.0	2.3	0.61	107.1
6	3	5.3	22.2	0.6	71.5	79.6	30.4	4.6	20.3	2.5	0.0	0.0	13.4	2.5	0.81	113.3
7	5	3.4	14.3	0.1	80.5	83.2	36.8	4.1	46.3	3.1	0.0	0.0	11.3	3.1	0.89	140.8
8	5	4.7	21.0	4.4	70.5	67.6	46.8	5.3	11.3	2.7	0.0	0.0	8.7	2.7	0.69	87.6
9	6	4.5	9.5	0.3	79.4	83.5	54.1	6.5	34.0	3.6	0.0	0.0	12.2	3.6	0.86	129.7
10	8	4.1	7.8	3.4	73.4	62.3	35.6	12.7	58.3	5.4	3.33	2.0	42.5	5.4	1.09	163.1
11	8	7.1	13.4	0.4	79.8	63.7	47.8	12.1	63.3	5.2	0.0	0.0	46.0	5.2	1.09	173.0
12	12	7.4	7.6	2.7	72.5	34.7	16.8	11.8	60.3	6.6	11.9	5.7	70.4	6.9	1.06	165.4
13	20	1.7	6.1	6.6	83.1	27.1	5.1	7.2	17.3	8.1	24.2	16.0	82.0	11.8	0.81	126.4
14	30	3.3	9.2	0.6	92.5	11.6	6.2	5.2	13.7	7.9	19.5	25.1	81.0	14.7	0.71	106.3
15	40	3.4	7.2	1.1	91.9	24.7	2.6	2.9	16.7	7.8	21.6	31.9	79.6	14.9	0.87	121.0
16	50	4.2	4.9	3.6	73.8	49.1	10.4	0.8	7.7	3.3	23.8	22.6	67.1	12.4	0.87	123.9
17	50	3.9	6.4	1.6	89.1	17.3	0.5	0.8	13.3	5.1	23.3	30.4	83.7	17.2	0.76	114.3
18	60	4.8	4.9	1.1	83.7	32.0	6.5	1.5	20.0	3.6	29.6	30.6	67.0	16.3	0.98	119.0
19	73	5.6	4.5	1.8	86.9	52.0	9.1	2.6	10.3	3.2	12.4	20.5	72.3	14.2	0.90	134.6
20	73	3.3	8.3	0.7	82.7	41.3	7.8	2.9	18.0	4.7	18.0	29.1	76.9	17.0	0.95	136.2
21	73	3.4	3.4	0.0	91.9	59.9	2.2	0.7	16.0	3.2	18.7	29.6	77.0	17.2	0.95	152.9
22	74	5.6	4.5	1.8	86.9	52.0	9.1	2.6	10.3	3.2	12.4	20.5	72.3	14.2	0.90	134.6
23	74	7.2	8.3	0.7	82.7	41.3	7.8	2.9	18.0	4.7	18.0	29.1	76.9	17.0	0.95	136.2

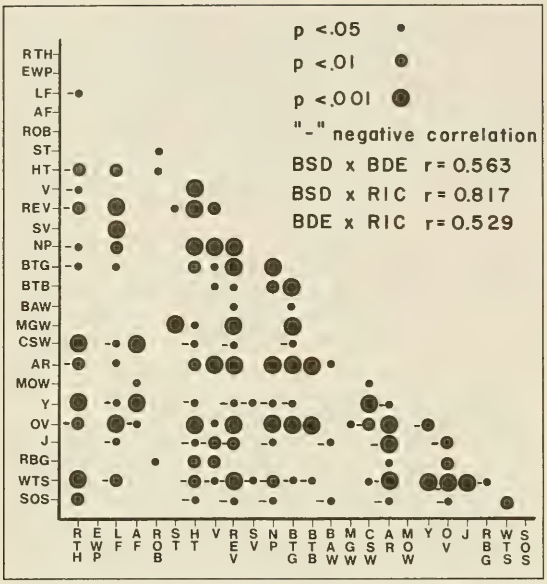

FIGURE 1. Correlation matrix of 24 bird species densities among 23 stands. See Appendix 1 for acronyms.

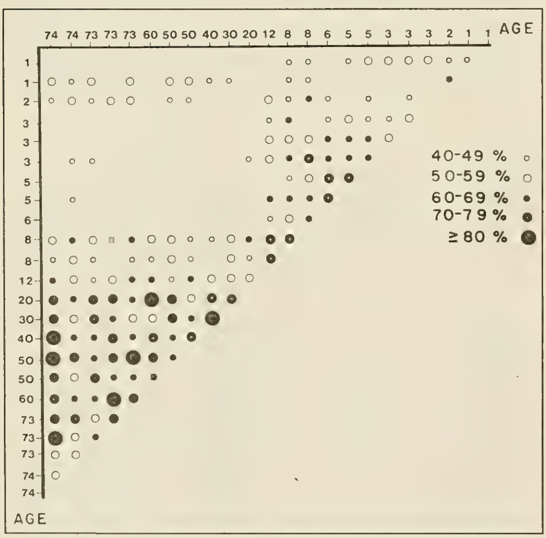

FIGURE 2. Matrix of coefficients of bird species similarity. Higher values represent greater similarity between pairs of sites.

found in shrubby habitats, suggesting greater flexibility of these species than of early seral ones.

Following Bond (1957), ΣS_s was calculated for each stand as an overall index of bird species similarity

TABLE 4. Ranking of sites from most to least similar. The indices of similarity of each stand to all other stands were summed. Indices of population similarity were similarly treated.

	Σ Species Similarity		Σ Population Similarity	
Rank	Site	Age	Site	Age
1	10	8	16	50
2	19	73	19	73
3	12	12	22	74
4	22	74	18	60
5	11	8	12	12
6	16	50	13	20
7	23	74	17	50
8	18	60	15	40
9	20	73	23	74
10	17	50	10	8
11	21	73	14	30
12	13	20	21	73
13	15	40	11	8
14	14	30	20	73
15	6	3	6	3
16	3	2	9	6
17	8	5	8	5
18	2	1	7	5
19	9	6	4	3
20	5	3	3	2
21	1	1	5	3
22	4	3	2	1
23	7	5	1	1

(Table 4). Communities ≤ 6 years old ranked low, and thus their species composition was relatively distinct in comparison with other stands. In contrast, the two 8 and one 12 year old stands had amongst the highest ΣS_s values, further suggesting that these intermediate-aged stands attract bird species of both young and mature habitats.

The coefficient of population similarity (S_p; Figure 3) differs from S_s in examining not only the presence of shared species, but also their densities. These data again show that stands closest in age had the most similar populations of species. However, compared with Figure 2 there were fewer highly similar sites. This sugggests that populations varied more between sites than did species composition. Total population similarities (ΣS_p; Table 4) again showed a distinct separation of young from older stands. However, compared with ΣS_s there was a shift towards older stands sharing more bird species having similar population densities.

A community cluster analysis was also run, based on stand data for all bird species with at least a portion of a territory. The amalgamation distance between each pair of stands (based on bird species densities)

was used to produce a dendrogram of bird community similarities (Figure 4). This clearly displays the separation of immature (≤ 12 years) from mature (≥ 20 years) avian communities. Additionally, when comparing the two major age groupings, we see that mature forest communities differed somewhat less from each other (i.e. shorter amalgamation distances) than did the immature habitat communities from each other. This likely reflects the much more rapid changes in bird species and density that characterize early succession.

Relationships Between Bird and Habitat Variables

The statistical relationships between avian and habitat variables were explored in a number of ways. The initial tests involved bivariate correlations between bird community variables (i.e. density, diversity, richness, and abundance of nesting or foraging guilds) or the abundance of selected bird species, with the various habitat variables listed in Appendix 1. This analysis revealed many significant ($p < 0.05$) relationships between avian and habitat variables (the matrices are presented in Morgan 1984). In fact, all avian variables were significantly correlated with at least several habitat variables. In part, this is due to the fact that many of the habitat variables were inter-correlated; ca. 53% of all possible correlations were significant at $p < 0.01$. In order to isolate and rank the most important habitat variables,we subjected the data to stepwise multiple regression (Table 5). The equations identify those habitat

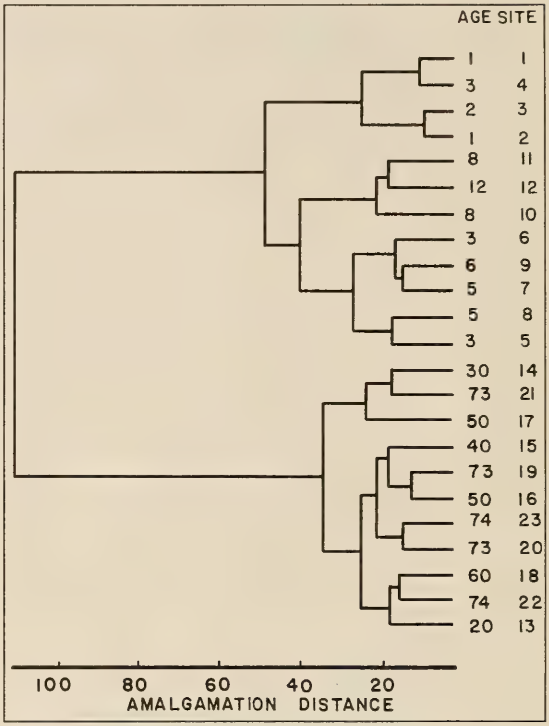

FIGURE 4. Dendrogram of amalgamation distances among all sites (based on bird species densities in an unweighted pair group cluster analysis). Shorter amalgamation distances indicate greater similarity between pairs of sites.

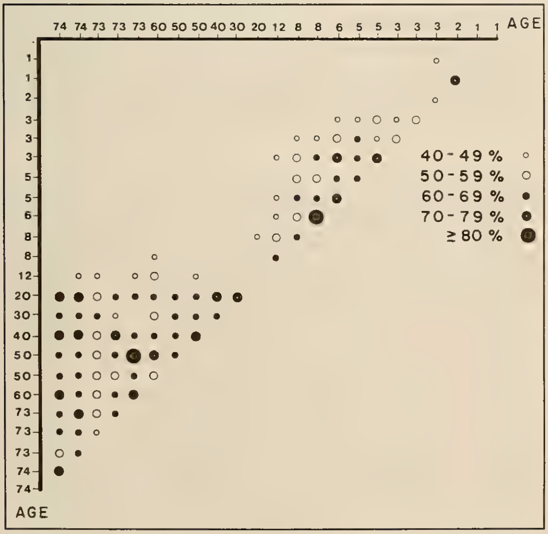

FIGURE 3. Matrix of coefficients of bird population similarity. Higher values represent greater similarity between pairs of sites.

variables which best account for variation in the avian variables. A value of equations such as these is in their potential powers of prediction, which could be tested by further field research in areas of similar vegetation and close geographic proximity. If this approach proves to be generally useful in predicting avian response to habitat change, it could be coupled with models of forest succession to predict the impact on breeding birds of particular forest management practices.

Because of problems of interpretation due to the inter-correlations of many of the habitat variables, we analyzed the data using principal components analysis (PCA), a multivariate test that is capable of extracting independent patterns of covariation. In this analysis, the components generated were orthogonal (uncorrelated) with each other. Table 6 summarizes the component patterns that resulted from the PCA of the immature, shrubby stands (≤ 12 years old). The first component accounted for 61.5% of the variation, and loaded heavily on variables that were strongly

related to stand age. Component 1 represented a gradient from stands characterized by high slash and herb cover, to stands with high stem basal area, tall shrubs, a dense canopy, and high foliage height diversity. The second PCA axis loaded most strongly on herb cover and shrub density, and accounted for an additional 22.6% of the variation. PCA axis 3 loaded mainly on slash cover, and accounted for only an additional 8.6% of variation, for a cumulative total of 93% for the first three PCA axes.

The factor scores of each stand upon each component were used to quantify a particular stand's position on each axis to facilitate correlations with avian variables (Table 7a). Bird species diversity was strongly ($p < 0.01$) correlated with PCA axis 1, a component combining both horizontal and vertical habitat complexity. This contrasts with the observations of Rotenberry and Wiens (1980), who found that avian diversity in grasslands was only correlated with vertical complexity. Richness, which was strongly correlated with bird diversity, was also correlated with axis 1, as was bird density. Thus, in immature stands, increasing horizontal and vertical complexity appeared to promote a greater variety and density of avifauna.

The densities of the most common immature stand bird species were also tested for correlations with the PCA axes (Table 7a). The strongest relationship occurred for the Northern Junco, which was negatively correlated ($p < 0.01$) with PCA axis 1, indicating a preference for relatively young stands with high slash cover and low development of horizontal and vertical plant structure. The strong correlation ($p < 0.01$) between the White-throated Sparrow and axis 3, as well as the weak correlation ($p < 0.1$) with axis 2, suggests a preference for stands characterized by high slash cover, abundant ground cover, and high shrub stem density. Yellowthroats and Chestnut-sided Warblers were only weakly correlated with any of the PCA axes. This does not necessarily imply the absence of a habitat response. Rather it indicates that either these species were responding to a multitude of factors, or that the habitat analysis was not sufficiently detailed.

The component loadings for the PCA of mature stand variables are listed in Table 8. Component 1 accounted for 37.1% of the variation, and most positively loaded on tree diameter and foliage height diversity, and most negatively on shrub height, shrub basal area, and canopy cover; these variables all respond strongly to stand age. Thus, PCA axis 1 represents a gradient from tall shrubs and saplings forming a dense, closed canopy, to larger diameter trees in stands with a vertically heterogeneous distribution of foliage. Component 2 accounted for an additional 30.3% of variation, and loaded most positively on tree basal area, canopy height, and shrub cover, and negatively on shrub density. Both tree basal area and canopy height increased with age, while shrub cover was only weakly correlated with tree basal area. Consequently, the role of shrub cover in axis 2 was probably marginal. This axis also represented a gradient related to age, ranging from stands with high shrub density to stands with high tree basal area and a high canopy. PCA component 3 accounted for 15.4% of the variation for a cumulative total of 83%, and represented a gradient from high to low tree density.

Again, avian variables were tested for correlation with the mature habitat PCA axes (Table 7b). Bird density was significantly negatively correlated with PCA axis 1, reflecting a decline in population in older stands with larger trees, even though they had a vertically more diverse distribution of foliage. This also suggests that the presence of tall shrubs and a closed canopy promotes greater bird density. Species richness was significantly negatively correlated with PCA axis 2, as was bird diversity although not significantly. This suggests that the development from stands of thin, short trees with high shrub density to stands with larger and taller trees and few shrubs contained the most important variables related to observed decreases in bird richness and diversity.

The densities of the most common bird species of the mature stands were also correlated with the PCA axes. The only significant relationships were the negative correlations between Black-throated Green Warbler, Red-eyed Vireo, and Ovenbird with axis 1, suggesting a preference for stands with tall shrubs and young trees creating a closed canopy, compared with stands of large diametered, tall trees and low shrubs. The other species were not significantly correlated with any of the PCA axes, suggesting that we may not have measured appropriate habitat variables.

Conclusions

Disturbance of this hardwood forest initially reduced density and diversity of the avian community. Bird species that invaded the newly created open habitat showed dramatic population increases over a short time. However, their occupancy was relatively short-lived, as species more typical of mature forests began to exploit the developing stands. Within as little as a decade, sufficient habitat regeneration had occurred (notably the establishment of a tall, dense shrub canopy, along with substantial vertical complexity) to allow re-establishment of some forest species. Thus, the transitional stage of succession between open brushy fields and a young, closed forest supported bird species common to both ends of the chronosequence.

TABLE 5. Stepwise multiple regressions for bird community and habitat variables. ALL = all sites; IMM = sites ≤ 12 years old; MAT = sites ≥ 20 years old.

Variable		Equation	n	r^2
Bird Species Diversity	ALL	BSD = 2.10 +0.026CAN –0.157CHT –0.129MSH –0.229TSD +0.051TOB	23	0.751
	IMM	BSD = 1.40 +0.033CAN –1.09FHD +0.011PHC –0.282TSD	12	0.966
	MAT	BSD = 4.22 –0.008PVC –0.029CAN –0.298TSD +0.012PLT	11	0.916
Bird Density (pairs/km^2)	ALL	BDE = 237 +73.6MSH –11.2PMS –364TSD +33.6TDI +329FHD	23	0.806
	IMM	BDE = –54.1 +1.29PUN +73.5SBA –14.1CAN +556FHD	12	0.896
	MAT	BDE = 2470 –0.725AGE –0.112TRD +0.408PLT –8.73PHC –67.7CHT	11	0.799
Species Richness	ALL	RIC = 10.9 –7.23FHD +1.48SBA +0.193AGE –3.98TSD –0.0001TST	23	0.588
	IMM	RIC = 11.8 +1.87SBA –8.97FHD –0.603TDI –0.0001SHD	12	0.955
	MAT	RIC = 50.6 –0.176PSC –0.003TRD –1.47CHT –1.09PMS –2.14TSD	11	0.709
Ground Nesters (% of total density)	ALL	GN = 39.6 –0.113CAN –0.066PLT +0.741PSL +1.10PMS +0.182PHC	23	0.869
	IMM	GN = 145 –0.555PLT –16.5CHT +8.28AGE –16.2TSD –0.398PHC	12	0.937
	MAT	GN = –74.0 +6.76PSL +1.99PLT +0.912PHC –0.833TDI –6.33 MSH	11	0.798
Cup Nesters (% of total density)	ALL	CN = 36.1 +0.171CAN +0.109PLT +0.582TDI –0.667PMS –0.517PSL	23	0.859
	IMM	CN = –28.3 +2.29TOB +0.435PLT +0.418TDI +0.528PHC –0.001TST	12	0.908
	MAT	CN = 88.3 –0.142PSL –0.783PLT +127FHD –0.959PUN –0.010TRD	11	0.776
Flycatchers (% of total density)	ALL	F = –2.68 +1.02AGE +5.08MSH –4.38CHT +0.008TRD	23	0.919
	IMM	F = –0.110 +0.399CAN –24.8TSD +0.029TRD	12	0.968
	MAT	F = –72.5 +113FHD +2.28SBA +0.001SHD –0.421PUN +0.218AGE	11	0.898
Ground Foragers (% of total density)	ALL	GS = –29.4 –25.8FHD –0.0004TST +1.34PSL +0.925PLT +1.72PMS	23	0.744
	IMM	GS = –52.6 –24.4FHD –0.001TST +1.27PLT +1.58PSL +1.99PMS	12	0.862
	MAT	GS = –178 +1.16PLT –3.83PSC +0.023TRD +27.2TSD +1.22CAN	11	0.778
Tree Foliage Gleaners (% of total density)	ALL	TFS = 99.0 +0.0008SHD –0.945PLT +2.65MSH –0.699PSL –0.972PMS	23	0.739
	IMM	TFS = 141 +0.001TST –1.28PLT –0.404TDI –1.23PSL –1.55PMS	12	0.703
	MAT	TFS = 9.83 +0.249PUN +0.303CAN –6.69TSD –0.310PHC +0.0003TST	11	0.819
Timber Gleaners (% of total density)	ALL	TG = 3.05 +0.773FHD –0.033PSL –1.51MSH +0.003TRD +0.845SBA	23	0.559
	IMM	TG = 1.86 +1.16TOB –2.56MSH +10.3FHD –0.032PVC	12	0.759
	MAT	TG = –6.18 –1.30PSL +1.49PMS +1.30CHT –0.076PVC +1.64TSD	11	0.827

TABLE 6. Results of principal components analysis of vegetation variables from young sites (1-12). See Appendix 2 for explanation of codes.

Principal components loading on vegetation variables	Component I	Component II	Component III
SHD	0.48	0.80	0.06
SBA	0.97	-0.06	0.05
CAN	0.92	-0.34	0.01
MSH	0.96	-0.21	0.08
PSC	0.91	-0.06	0.32
PHC	-0.21	0.93	0.15
PLT	0.62	0.59	-0.33
PSL	-0.68	0.02	0.68
FHD	0.92	0.09	0.27
Eigenvalue	5.532	2.034	0.778
Variation explained	61.5%	22.6%	8.6%
Cumulative %	61.5%	84.1%	92.7%

TABLE 7. Correlations between avian community variables and species with principal component axes for immature and mature sites.

	Principal Component I	Principal Component II	Principal Component III
a) *Immature Sites* (≤12 years old)			
BSD	0.79*	-0.16	-0.13
BDE	0.69**	0.41	0.40
RIC	0.80*	-0.13	0.03
Y	0.38	0.43	0.54****
CSW	0.56****	0.44	-0.02
J	-0.79*	0.19	0.15
WTS	-0.29	0.53****	0.73*
b) *Mature Sites* (≥20 years old)			
BSD	-0.20	-0.51	-0.27
BDE	-0.65***	-0.26	0.04
RIC	0.09	-0.69***	0.26
LF	0.09	-0.19	0.03
BAW	-0.23	-0.39	-0.35
AR	-0.35	-0.29	-0.07
BTG	-0.78*	-0.06	0.13
OV	-0.69**	-0.01	0.43
REV	-0.72**	-0.25	0.16
HT	-0.50	0.21	-0.17

*$p < 0.01$
**$p < 0.02$
***$p < 0.05$
****$p < 0.10$

TABLE 8. Results of principal components analysis of vegetation variables from mature sites (13-23). See Appendix 2 for explanation of codes.

Principal components loading on vegetation variables	Component I	Component II	Component III
TRD	-0.32	0.40	-0.84
TBA	0.36	0.85	-0.09
TDI	0.80	0.09	0.56
CAN	-0.64	0.49	0.55
CHT	0.52	0.79	0.24
SHD	0.34	-0.79	-0.08
SBA	-0.77	-0.20	0.19
MSH	-0.89	0.26	0.11
PSC	-0.09	0.74	-0.18
FHD	0.79	0.07	-0.24
Eigenvalue	3.709	3.028	1.544
Variation explained	37.1%	30.3%	15.4%
Cumulative %	37.1%	67.4%	82.8%

Bird species within the same foraging guilds tended to respond in similar fashions to the destruction and regrowth of the forest. By the time the stands had outgrown the early period of rapid vegetation changes, major foraging guilds appeared to approach a balance.

Many more bird species were encountered over the chronosequence than in any single stand. Although this was partly due to the increased aggregate area studied, it also was undoubtedly a result of increased habitat heterogeneity (including a mosaic of young and mature stands; this is equivalent to the β-diversity of MacArthur (1965)). If a rich regional avifauna was a management objective, this could be achieved by maintaining the forest as a patchwork of different successional stages. Only those species that have very specific habitat requirements or demand very large territories would likely be affected adversely by clearcutting of the sort studied here; however, larger-tract clearcutting would probably have greater effects on the avifauna. It is likely that the greater ecological flexibility of the more common bird species, especially those typical of mature stands, would permit forest managers to manipulate sites with the rarer species in mind.

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Appendix 1. Common and scientific names of birds and plants mentioned in the text. Birds follow AOU (1983), and plants follow Roland and Smith (1969).

Birds
Red-tailed Hawk — *Buteo jamaicensis*
Merlin — *Falco columbarius*
Common Snipe — *Gallinago gallinago*
Ruffed Grouse — *Bonasa umbellus*
Common Nighthawk — *Chordeiles minor*
Chimney Swift — *Chaetura pelagica*
Ruby-throated Hummingbird — *Archilochus colubris*
Pileated Woodpecker — *Dryocopus pileatus*
Common Flicker — *Colaptes auratus*
Yellow-bellied Sapsucker — *Sphyrapicus varius*
Downy Woodpecker — *Picoides pubescens*
Hairy Woodpecker — *Picoides villosus*
Eastern Wood Pewee — *Contopus virens*
Olive-sided Flycatcher — *Contopus borealis*
Yellow-bellied Flycatcher — *Empidonax flaviventris*
Least Flycatcher — *Empidonax minimus*
Alder Flycatcher — *Empidonax alnorum*
Tree Swallow — *Tachycineta bicolor*
Northern Raven — *Corvus corax*
Blue Jay — *Cyanocitta cristata*
Gray Jay — *Perisoreus canadensis*
Black-capped Chickadee — *Parus atricapillus*
White-breasted Nuthatch — *Sitta carolinensis*
American Robin — *Turdus migratorius*
Swainson's Thrush — *Catharus ustulatus*
Hermit Thrush — *Catharus guttatus*
Veery — *Catharus fuscescens*
Gray Catbird — *Dumetella carolinensis*
Cedar Waxwing — *Bombycilla cedrorum*
Red-eyed Vireo — *Vireo olivaceus*
Solitary Vireo — *Vireo solitarius*
Northern Parula — *Parula americana*
Black-throated Green Warbler — *Dendroica virens*
Black-and-white Warbler — *Mniotilta varia*
Black-throated Blue Warbler — *Dendroica caerulescens*
Magnolia Warbler — *Dendroica magnolia*
Yellow-rumped Warbler — *Dendroica coronata*
Canada Warbler — *Wilsonia canadensis*
Chestnut-sided Warbler — *Dendroica pensylvanica*
Bay-breasted Warbler — *Dendroica castanea*
Blackburnian Warbler — *Dendroica fusca*
American Redstart — *etophaga ruticilla*
Tennessee Warbler — *Vermivora peregrina*
Nashville Warbler — *Vermivora ruficapilla*
Mourning Warbler — *Oporornis philadelphia*
Common Yellowthroat — *Geothlypis trichas*
Northern Waterthrush — *Seiurus noveboracensis*
Ovenbird — *Seiurus aurocapillus*
Rose-breasted Grosbeak — *Pheucticus ludovicianus*
Song Sparrow — *Melospiza melodia*
White-throated Sparrow — *Zonotrichia albicollis*
Dark-eyed (Northern) Junco — *Junco hyemalis*
Rusty Blackbird — *Euphagus carolinus*
Purple Finch — *Carpodacus purpureus*
Red Crossbill — *Loxia curvirostra*
White-winged Crossbill — *Loxia leucoptera*
American Goldfinch — *Carduelis tristis*
Evening Grosbeak — *Coccothraustes vespertinus*

Plants
Red Spruce — *Picea rubens*
Red Maple — *Acer rubrum*
Sugar Maple — *Acer saccharum*
Striped Maple — *Acer pensylvanicum*
Paper Birch — *Betula papyrifera*
Yellow Birch — *Betula allegheniensis*
American Beech — *Fagus grandifolia*

White Ash — *Fraxinus americana*
Hazelnut — *Corylus cornuta*
Witch-hazel — *Hamamelis virginiana*
Speckled Alder — *Alnus rugosa*
Pin Cherry — *Prunus pensylvanica*
Witherod — *Viburnum cassinoides*
Bush-honeysuckle — *Diervilla lonicera*
Fly-honeysuckle — *Lonicera canadensis*
Raspberry + Blackberry — *Rubus* spp.
Wild Sarsaparilla — *Aralia nudicaulis*
Bunchberry — *Cornus canadensis*
Wood Fern — *Dryopteris spinulosa*
Hay-scented Fern — *Dennstaedtia punctilobula*
Bracken Fern — *Pteridium aquilinum*

Appendix 2. Acronyms for avian and habitat variables.

Variable	Code
Bird density	BDE
Bird species diversity	BSD
Richness	RIC
Ground nesters	GN
Cup nesters	CN
Flycatchers (and hoverers)	F
Ground (and slash) foragers	GS
Foliage gleaners	TFS
Timber gleaners	TG
Ruby-throated Hummingbird	RTH
Eastern Wood Pewee	EWP
Least Flycatcher	LF
Alder Flycatcher	AF
American Robin	ROB
Swainson's Thrush	ST
Hermit Thrush	HT
Veery	V
Red-eyed Vireo	REV
Solitary Vireo	SV
Northern Parula	NP
Black-throated Green Warbler	BTG
Black-throated Blue Warbler	BTB
Black-and-white Warbler	BAW
Magnolia Warbler	MGW
Chestnut-sided Warbler	CSW
American Redstart	AR
Mourning Warbler	MOW
Common Yellowthroat	Y
Ovenbird	OV
Northern Junco	J
Rose-breasted Grosbeak	RBG
White-throated Sparrow	WTS
Song Sparrow	SOS
Percent slash cover	PSL
Percent mineral soil	PMS
Percent litter cover	PLT
Percent herb cover	PHC
Shrub density	SHD
Shrub basal area	SBA
Percent shrub cover	PSC
Maximum shrub height	MSH
Tree density	TRD
Tree basal area	TBA
Tree diameter	TDI
Tree species diversity	TSD
Percent canopy cover	CAN
Canopy height	CHT
Total stem density (SHD + TRD)	TST
Total basal area (SBA + TBA)	TOB
Foliage height diversity	FHD
Percent vegetation cover	PVG
Percent vertical cover	PVC
Percent understory cover	PUN
Age	AGE

Influence of Selective Logging on Red-shouldered Hawks, *Buteo lineatus*, in Waterloo Region, Ontario, 1953-1978

ANDREW A. BRYANT

Department of Biology, University of Waterloo, Waterloo, Ontario N2L 3G1
Present address: Faculty of Environmental Design, University of Calgary, Calgary, Alberta T2N 1N4

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Nest records and aerial photographs spanning the period 1953-1978 were analysed to identify land-use changes associated with territory abandonment by Red-shouldered Hawks (*Buteo lineatus*) or the replacement of that species by Red-tailed Hawks (*Buteo jamaicensis*). Incursions by Red-tailed Hawks were strongly associated with reductions in mean tree density and tree-crown diameter. This suggests that selective cutting in woodlots may result in the replacement of Red-shouldered Hawks by Red-tailed Hawks. Failure to maintain uncut buffer zones around traditional Red-shouldered Hawk nest sites may result in the local extirpation of this species.

Key Words: Red-shouldered Hawk, *Buteo lineatus*, Red-tailed Hawk, *Buteo jamaicensis*, selective logging, Ontario.

Recent declines of Red-shouldered Hawk (*Buteo lineatus*) populations have been documented continent-wide (e.g. Brown 1971; Fyfe 1976; Nagy 1977), and in various specific locales (e.g. Wallace 1969; Quilliam 1973; Wiley 1975; Bednarz and Dinsmore 1981). Red-tailed Hawk (*Buteo jamaicensis*) populations have remained stable or have increased during this same period (Brown 1964; Wallace 1969; Fyfe 1976; Nagy 1977). Statements that Red-tailed Hawks are replacing Red-shouldered Hawks over much of the latter's range have been made by Brown (1964), Peterson (1969), and Quilliam (1973). Numerous explanations have been proposed for this replacement.

Craighead and Craighead (1956) suggested that timber cutting and intensive agriculture create conditions more favourable to red-tails. Campbell (1975) postulated that drainage for agriculture may reduce the numbers of amphibian prey available to Red-shouldered Hawks. Galli et al. (1976) and Robbins (1979) believed that Red-shouldered Hawks require a contiguous forested area of at least 10 to 100 hectares. Bednarz and Dinsmore (1981, 1982) supported this idea, and suggested that forest clearing and pasture development have shifted the competitive advantage from red-shoulders to red-tails. Armstrong and Euler (1982) thought that even small-scale clearing for cottage development could fragment riparian woodland habitats and influence breeding success. These hypotheses remain conjectural because no researcher has correlated the abandonment of Red-shouldered Hawk territories with historical data on land-use change. Thus, land managers lack specific information on how to maintain viable Red-shouldered Hawk habitat.

In this study I tested whether land-use changes were associated with territory abandonment or species replacement. My hypothesis was that traditional Red-shouldered Hawk territories which were abandoned, or which were occupied by Red-tailed Hawks, would be different (in terms of land-use/habitat conditions) from those occupied by the original (red-shouldered) species.

Study Areas

Waterloo Region is situated in central southern Ontario, on the border between the Carolinian and Mixedwood forest regions of Canada (Soper 1956); see Figure 1. The topography is glaciated, with rolling hills and numerous kettle lakes, swamps, streams and rivers. The area is mostly agricultural but with a growing urban core; woodlands, swamps and marshes comprise only 13% of the total surface area (unpublished data, Waterloo Regional Municipality, 1976). Woodlands are typically dominated by Sugar Maple (*Acer saccharum*) and Beech (*Fagus grandifolia*). Oaks (*Quercus* spp.), ashes (*Fraxinus* spp.), Hemlock (*Tsuga canadensis*) and Eastern White Cedar (*Thuja occidentalis*) occur in varying amounts. Many woodlots are selectively cut under the Woodlands Improvement Act (W.I.A.) administered by the Ministry of Natural Resources.

Surveys carried out for the Canadian Wildlife Service by Campbell (1975; C. A. Campbell, unpublished data) provide background information on nesting Red-shouldered Hawks within Waterloo Region. Historically they were considered to be the most common nesting *Buteo*, but a sharp decline has occurred recently (Campbell 1975). Twelve breeding pairs found in 1973 were reduced to 4 in 1978, 3 in

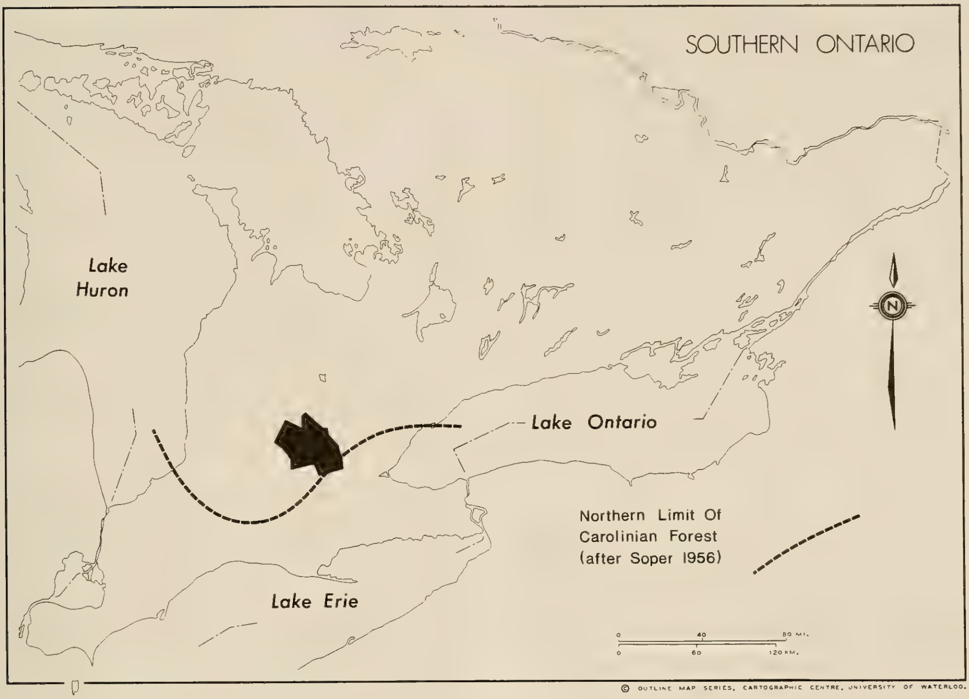

FIGURE 1. Location of Waterloo Region, Ontario.

1979 (Sharp and Campbell 1982) and 3 in 1983 (A. Bryant and P. Taylor, personal observation). Red-tailed Hawks simultaneously increased in number and are now the most widespread *Buteo* in the Region (unpublished data, Ontario Breeding Bird Atlas).

Methods

Information on nesting raptors was obtained from a variety of sources (see Acknowledgments). Data collected were year of occupancy, species, and location of nest.[1] A territory was considered "occupied" if birds were found incubating on the nest, if two adult birds were observed displaying territorial behaviour, or if an adult with young was seen. Records of non-brooding single birds were not used. "Doubly-occupied" territories were those where the hunting ranges of two species overlapped. Red-shouldered and Red-tailed hawk hunting ranges were assumed to be 1.4 and 2.0 km in diameter, respectively (after Craighead and Craighead 1956), circular in shape and centered on the nest tree. "Absence" was assumed if the area was surveyed during the breeding season and no hawks were seen.

Using these criteria, four ocupancy classes were defined. These were RSH — Red-shouldered Hawk alone, RTH — Red-tailed Hawk alone, RSH + RTH — Red-shouldered and Red-tailed hawks, and NONE — no occupant. Records for Red-tailed Hawk ranges which did not overlap historical Red-shouldered Hawk ranges were discarded; the inclusion of such records would not have contributed to the understanding of territory abandonment by Red-shouldered Hawks.

Habitat and land-use parameters at 22 historical Red-shouldered Hawk sites were measured using 1:10 000 and 1:15 840 scale aerial photographs. Air photos were available for 1955, 1966, 1968, 1972, 1975 and 1978; 53 air photo pairs were analysed in total. Sampling was neither strictly systematic nor random; it depended on the availability of hawk presence/absence data and usable stereo air photo coverage.

The assumption was made that photos would illustrate land-use changes which had occurred up to two years prior to the actual photo date, and could

[1]Copies of the raptor occupancy data for Waterloo Region, 1953-1985, may be obtained by writing the author.

therefore be used to quantify habitat conditions which existed in years for which no photographs were available. On 33 occasions occupancy data corresponded exactly to photo date, on 9 occasions photos were assumed to portray habitat conditions existing one year prior to photo date, and on 11 occasions they were assumed to portray conditions existing two years prior to photo date.

At 4 of 22 sites it was possible to distinguish actual nest trees on air photos; at the remaining 18 sites the nest was assigned to a particular tree on the basis of nest-record descriptions. Some nests were probably misplaced by this method; in addition, *Buteo* hawks sometimes build and use several different nests in the same woodlot. I assumed that the assignment of a constant nest tree for each site would be an appropriate means of detecting land-use changes.

Twelve variables were measured from each photo pair; each measurement was made three times and averaged. The 12 variables, and methods used to quantify them, were:

WOODSIZE: The sizes of contiguous (not dissected by roads, hydro corridors etc.) wooded areas were measured with a random dot grid (after Brewer and McCann 1982) and expressed in hectares.

DISTEDGE: The distance between the nest tree and the nearest artificial or natural forest edge was measured with a wedge scale (after Spurr 1960) and expressed in metres.

DISTHAB: The distance from the nest tree to the nearest dwelling or other construction subject to frequent human use was measured with a wedge scale and expressed in metres. Small pump houses or utility sheds were not included in this category.

DISTWAT: The distance between the nest tree and the nearest open water was measured with a wedge scale and expressed in metres. Small swales and swampy areas were often not visible on air photos. DISTWAT values are therefore overestimated.

CANHT: The average height of the tree canopy in metres was calculated from parallax measurements made with a floating-dot type parallax bar (after Lillesand and Kiefer 1979).

CROWNDIA: The average tree-crown diameter was measured as follows: an acetate overlay transect (equivalent to 100 ground metres) was centered on the nest tree and oriented so as to minimize parallax distortion along it (i.e. perpendicular to a radial line originating on the principal point: Lillesand and Kiefer 1979). The first 10 tree crowns encountered along this transect were measured with the parallax bar used as a micrometer (American Society of Photogrammetry 1960) and averaged.

TREEDENS: Tree density was measured as follows: the 100 (scale) metre transect was again "travelled" with the parallax bar. Widths of gaps in the crown cover were recorded, totalled and subtracted to yield a % crown closure or tree density value.

PROPWOOD: The proportion of woodland in territory was measured by centering a 1.4 km (scale) diameter circular acetate "territory" on the nest tree. The quantity of woodland inside this range was measured with a dot grid and expressed as a proportion of the total area.

PROPCULT: Cultivated areas were identified on the basis of texture (after Spurr 1960) and measured as above.

PROPFALL: The proportion of fallow area in a territory was identified and measured as above. Fallow areas were defined as pasture, hayfields and other uncultivated grassland habitats.

PROPURB: The proportion of urban area in a territory was measured as above. This category included residential areas, industrial land, and built-up urban areas.

PROPOTH: The proportion of "other" area in territory was measured as above. This was a catch-all category which included a golf course, gravel pits, highways, large rivers, newly reforested areas, and land under development.

The means of habitat/land-use parameters were calculated for each of the four occupancy classes (Table 1). All further statistical treatments were performed with data from two occupancy classes only (Red-shouldered Hawk alone and Red-tailed Hawk alone), as sample sizes in the other classes were too small. Univariate and multivariate analysis of variance were used to test the null hypothesis that historical Red-shouldered Hawk territories occupied by Red-tailed Hawks were no different from those occupied by the former species. A canonical discriminant function analysis was used to calculate the relative contribution of each variable to differences in occupant type, and to assess the predictive capability of the habitat variables. All computer analyses were run using the Statistical Analysis System (SAS Institute Inc., 1982).

Results

Data on 22 historical Red-shouldered Hawk sites yielded 33 instances of RSH occupancy, 13 instances of RTH occupancy, 3 cases of RSH + RTH, and 4 cases of NONE. In addition there was one record of occupancy by Great Horned Owls (*Bubo virginianus*), and one record of occupancy by all three species; these latter data were not used in the analysis.

My results support the hypothesis that land-use conditions influence the type of *Buteo* occupant. (Results of MANOVA: Wilk's criterion = 0.3420, Prob < 0.0001. The null hypothesis that land-use

TABLE 1. Habitat/land-use parameter means and standard deviations by occupancy class. * denotes significance as determined by ANOVA (Probability < 0.05). Only the first two classes were used in the analysis.

Variable	RSH	RTH	RSH + RTH	NONE
	$\bar{x}$ s.d.	$\bar{x}$ s.d.	$\bar{x}$ s.d.	$\bar{x}$ s.d.
WOODSIZE (ha)	17.5 ± 14.9	17.0 ± 16.0	13.4 ± 8.6	3.9 ± 2.7
DISTEDGE (m)	61.8 ± 36.6	51.1 ± 25.5	85.0 ± 35.0	41.7 ± 27.2
DISTHAB (m)	229.5 ± 131.6	277.9 ± 138.1	310.0 ± 156.3	166.5 ± 172.9
DISTWAT (m)	239.7 ± 207.9	367.9 ± 295.7	453.3 ± 255.8	436.2 ± 323.9
CANHT (m)	17.7 ± 2.5	18.0 ± 1.7	15.8 ± 2.3	17.4 ± 3.0
CROWNDIA (m)	* 8.0 ± 1.3	* 6.9 ± 0.8	7.1 ± 1.6	5.2 ± 1.3
TREEDENS (%)	* 74.0 ± 6.6	* 64.0 ± 5.3	67.7 ± 10.8	53.3 ± 15.8
PROPWOOD (%)	27.4 ± 11.5	26.1 ± 11.2	22.3 ± 9.6	21.5 ± 9.0
PROPCULT (%)	25.4 ± 20.0	33.3 ± 19.3	34.7 ± 13.6	20.5 ± 26.4
PROPFALL (%)	15.4 ± 12.7	19.6 ± 10.0	23.0 ± 8.7	12.0 ± 12.2
PROPURB (%)	21.4 ± 27.1	11.4 ± 13.0	14.0 ± 15.1	32.2 ± 23.7
PROPOTH (%)	9.5 ± 11.6	9.8 ± 7.7	5.3 ± 2.1	13.2 ± 9.0
	n = 33	n = 13	n = 3	n = 4

conditions do not influence occupant type was rejected). ANOVA found that two variables, CROWNDIA and TREEDENS, were significantly different between the two tested occupancy classes. Historical Red-shouldered Hawk territories occupied by Red-tailed Hawks had significantly fewer and smaller tree-crowns than did territories maintained by Red-shouldered Hawks. Differences in the means of DISTWAT, DISTHAB, PROPCULT and PROPURB were visible between occupancy classes but these were not significant. No difference was evident between WOODSIZE values for the two tested occupancy classes.

A canonical discriminant function analysis was performed to explore these data further. This analysis seeks to explain the variation within a multidimensional data "cloud" in terms of artificial (canonical) axes which are produced from weighted combinations of the variables (Bennet and Bowers 1976). Such analysis reveals two things. It shows whether two (or more) groups are significantly different along these canonical axes, i.e., on the basis of all the measured variables. More importantly, the weighting of variables discloses which ones contribute most to the total variation expressed along the canonical axes and hence which individual variables contribute most to the separation of groups.

Because only two classes were compared, CDFA generated only one canonical axis. Red-shouldered and red-tailed occupancy classes were found to be significantly different along this axis (F = 5.290 with 12/33 D.F., Prob < 0.0001). In addition, the red-shouldered data show a pronounced kurtosis, whereas the red-tailed data are more evenly spaced around their respective canonical class means (Figure 2). This may indicate wider tolerance of habitat variation by Red-tailed Hawks.

TREEDENS and CROWNDIA contributed significantly (P < 0.05) to the separation of the two groups along the canonical axis (canonical coefficients of 0.7289 and 0.4598 respectively). The contributions of all other variables were found to be non-significant. A classification program was run to test the utility of a discrimination model based on TREEDENS and CROWNDIA. Using these two criteria, 30 of 33 red-shouldered occupants, and 11 of 13 red-tailed occupants were classified correctly. Therefore, the variables TREEDENS and CROWNDIA have a high utility for predicting occupant species.

Discussion

Air photo analysis of historical Red-shouldered Hawk territories provides strong evidence that land-use changes have influenced the decline of this species in Waterloo Region.

Three territories suffered such extensive clearing and residential development that they probably can no longer be considered suitable nesting habitat for any woodland raptor species. The remaining 19 sites have not undergone such extensive habitat modification, thus implying that gross habitat destruction is not the most important factor in the decline of Red-shouldered Hawks in this part of Ontario.

Twelve of 22 Red-shouldered Hawk sites were occupied by Red-tailed Hawks on one occasion or more; at least three sites have suffered an apparently permanent species replacement. This suggests that territorial exclusion by Red-tailed Hawks may be an

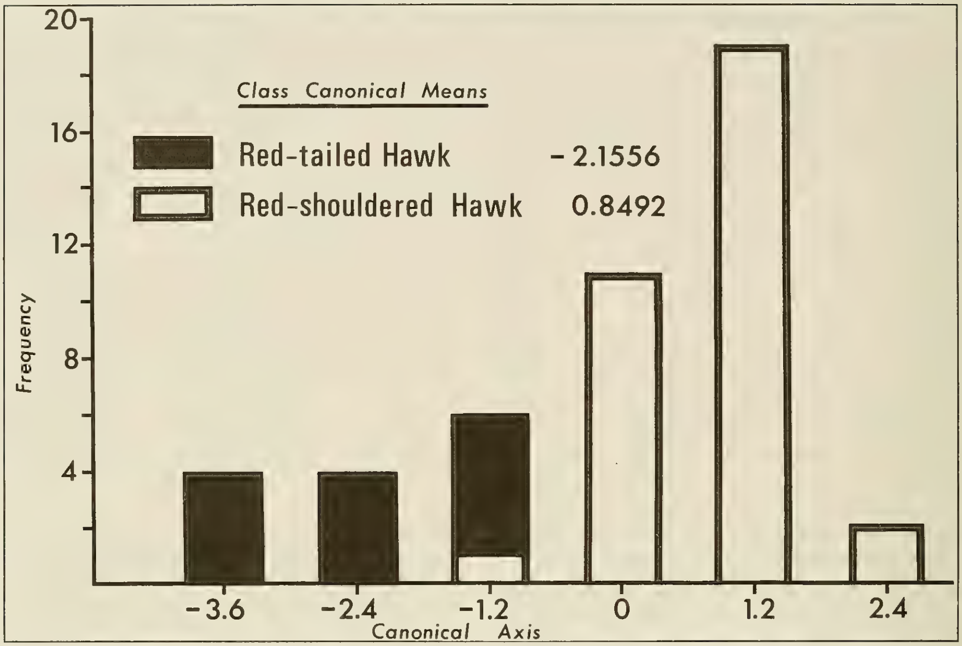

FIGURE 2. Frequency and mean value for Red-tailed and Red-shouldered occupancy classes along canonical axis. Good separation between classes was found on the basis of the measured variables.

important proximate factor in the decline of Red-shouldered Hawks in this area. Bent (1937) said that "the red-tailed and red-shouldered hawk never nest near together", called the two species "competitive and antagonistic", and reported an instance of predation by the former upon the latter. Stewart (1949) attributed the absence of red-shoulders from an apparently suitable nesting habitat to the presence of nesting red-tails. Craighead and Craighead (1956) postulated that territorial exclusion can occur because the hardier red-tails can move into and defend territories before red-shoulders return from migration.

Bednarz and Dinsmore (1981, 1982) believed that woodland loss, fragmentation and conversion to agriculture may increase interspecific competition and so facilitate species replacement. My results indicate that these processes were of little importance in Waterloo Region. Woodlot size and the proportion of wooded land remained remarkably constant over time; moreover, these values were not significantly smaller at sites occupied by red-tails. Similarly, the proportion of cultivated land did not increase appreciably over time and was not significantly greater at sites occupied by red-tails.

Red-tailed Hawk incursions were associated with decreased tree densities and crown diameters, suggesting that these incursions were a response to selective logging in woodlots (selective cutting would reduce average crown diameter through removal of the largest, most mature trees, and would obviously lower tree density). Red-tails were apparently unable to displace Red-shouldered Hawks from mature forest with high crown closure values (>70%), even in small (>5 ha) woodlots. I believe that selective logging permits territory appropriation by the larger, more aggressive but less manoeuverable red-tails, and that cutting for timber or firewood may be ultimately responsible for the decline of Red-shouldered Hawks in Waterloo Region.

This conclusion has important management implications. A returning pair of Red-shouldered Hawks will not likely experience territorial exclusion if their traditional nest site is in a dense (though perhaps small) woodlot. However, extensive selective cutting in large woodlots may open up whole regions to local extinction of red-shoulders through red-tail encroachment. Landowners must be persuaded to leave a completely uncut buffer zone around traditional Red-shouldered Hawk nest sites in order

to discourage red-tails. Additional research should be directed towards monitoring red-tail encroachment and refining estimates of tree densities needed to exclude red-tails.

Acknowledgments

Information on nesting raptors was obtained from the Ontario Nest Records Scheme (O.N.R.S.), the Ontario Breeding Bird Atlas, local naturalists, and various field survey reports on "Environmentally Significant Policy Areas" as designated by the Regional Municipalilty of Waterloo. Special mention must be made of the hawk records maintained by C. A. Campbell, without which this study would have been far more difficult. This research was conducted in partial fulfillment of the requirements for a Bachelor of Environmental Studies (B.E.S.) degree. D. Dudycha and S. Smith assisted with the selection of the statistical methods. P. Taylor helped with the initial field observations. I thank D. Bird, A. Erskine, S. Smith and P. Taylor for their helpful comments on the manuscript. Partial funding for this project was provided by the James L. Baillie Fund for bird research and preservation.

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Dry Grassland Plant Communities in Wood Buffalo National Park, Alberta

ROBERT E. REDMANN and ARTHUR G. SCHWARZ

Department of Crop Science and Plant Ecology, University of Saskatchewan, Saskatoon, Saskatchewan S7N 0W0

Redmann, Robert E., and Arthur G. Schwarz. 1986. Dry grassland plant communities in Wood Buffalo National Park, Alberta. Canadian Field-Naturalist 100(4): 526–532.

Four dry grassland sites in Wood Buffalo National Park were found to contain plant species typical of grassland vegetation much farther south in the Prairie Provinces. Grassland stands in the Salt River area, dominated by *Stipa curtiseta* and *Danthonia californica*, were similar to the grassland of the Peace River district described by E.H. Moss. Sites in the Peace Point area had *Stipa columbiana, S. curtiseta* and *S. comata* as important components. Disturbance from compaction and erosion caused increases in *Carex obtusata, Koeleria macrantha* and several forbs, and decreases in *Stipa* spp. Analysis of soil characteristics supported earlier hypotheses that edaphic conditions cause the unusual occurrence of these grasslands in the boreal forest zone.

Key Words: Grassland ecology, grassland vegetation, northern grasslands, plant-soil relationships, Wood Buffalo National Park, Alberta.

The boreal forest cover of Wood Buffalo National Park (WBNP) is interrupted in places by grassland vegetation. These "prairies" are predominantly wet meadows dominated by *Carex* spp. and *Calamagrostis* spp., or by halophytic vegetation on the more saline soils (Raup 1935). (Common names are given in the Appendix.) Also present are smaller dry grassland communities which include plant species typical of true grasslands located much farther south. Jeffrey (1961) reports that forest encroachment has reduced the extent of grasslands at Peace Point, WBNP, first described in 1928 (Raup 1935).

Other authors have mentioned the WBNP grasslands (Moss 1952, 1955; Wilkinson and Johnson 1983), but we were unable to find any published survey of the grasslands' composition or distribution since Raup's pioneering work. In 1982 and 1983 we located two dry grassland sites 22 km south of Fort Smith, NWT. These were not mentioned by Raup, and lie farther north than any dry grasslands which he described. The objectives of our research were to sample and describe the dry grassland vegetation of these sites, to re-examine the Peace Point grasslands and to relate the distribution of these communities to soil conditions, other ecological factors, and the regional vegetation distribution.

Study Area

Location

Two study sites were located near the Salt River (59°48′N, 112°00′W) and two at Peace Point, Alberta (59°06′N, 112°25′W). All sites were in Wood Buffalo National Park (WBNP), except for the Salt River location (SR), which was just outside the boundary on the north bank of the Salt River. The Benchmark Creek (BC) site was 2-3 km southeast of SR, south of the Salt River. The Peace Point (PP) site was on a terrace above the north bank of the Peace River, and the fourth site (PE) was located along the escarpment about 1 km north of PP.

Physical Features

Wood Buffalo National Park occupies parts of the Alberta Plateau and Mackenzie Lowlands physiographic provinces (Raup 1946). Bedrock, consisting of Paleozoic dolomites, limestones and shales, occurs as outcrops along the Salt River and Peace River, near the study sites. A mantle of till, outwash and lacustrine and alluvial deposits covers the bedrock. Glacial re-working of relatively soft, horizontal beds of limestone, dolomite and gypsum has contributed to the calcicoly in the flora of the park (Raup 1946). Salt springs rising from bedrock southwest of Fort Smith have produced extensive salt plains with halophytic vegetation.

The study sites all lie on what Raup (1946) refers to as the 800-ft level of the glacial lake which once occupied the region. Poorly-drained clayey soils of these glaciolacustrine sediments are positively correlated with wet grassland distribution in WBNP (Raup 1935). Soils of the Peace Point grassland developed in glaciolacustrine sediments of silty to fine-sandy texture overlying till on Devonian gypsum (Jeffrey 1961) and are better drained than the wet grassland soils in WBNP. Although heavy clayey soils underlie the Salt River and Benchmark Creek sites, local relief results in better surface drainage.

The climate of WBNP is classified as Boreal, a type with cool, moist summers and very cold winters which

last for more than six months (Walter et al. 1975). The closest weather station is Fort Smith, NWT, where long-term mean daily temperature is -3.2° C (Hare and Hay 1974). Mean annual precipitation totals 337 mm; snowfall averages 140 cm. Average temperature and total precipitation for the May-September period are 11.8°C and 187 mm. Macroclimatic conditions are outside the range associated with climatic-climax grassland vegetation (Walter et al. 1975).

Methods

Homogeneous stands were selected for sampling at each study site. Only better drained locations on relatively higher topographic positions and generally south-facing slopes were sampled. This excluded wet grassland dominated by *Carex* spp. and *Calamagrostis* spp. Areas disturbed by compaction and erosion were sampled separately from relatively undisturbed locations.

In each stand a baseline was established, oriented up and down the slope gradient, in order to include any variation in composition due to slope position. Vegetation was sampled at 5 m intervals along this baseline using a 50 × 25 cm quadrat frame. Between 1 and 4 baselines and 9 and 20 quadrats were sampled in each stand. Cover for each species was estimated using a five-point scale: 1, 90-100%; 2, 50-90%; 3, 10-50%; 4, 1-10%; and 5, present but < 1% cover. Mid-points of these ranges were used to calculate mean cover for each species in a stand. Only vascular plants were sampled. Adequacy of sampling in a stand was determined by plotting species-area curves using species in cover classes 1-4. The fewest quadrats were sampled in the disturbed stands. These were smaller and less diverse.

Voucher specimens, collected under Parks Canada Permit 83-12, have been deposited in the W. P. Fraser Herbarium, University of Saskatchewan (SASK). Nomenclature follows Moss (1983).

The undisturbed grassland sites in WBNP were compared with the *Agropyron-Stipa* and *Stipa* grasslands of the Peace River region using data presented in Moss (1952: 116). The eight most dominant graminoid species in each region were assigned a rank value from 8 (most-dominant) to 1 (least-dominant), based on cover. The eight most dominant forb species were also ranked. A dominance similarity index (S) was calculated as

$$S = \left(\frac{\Sigma a}{\Sigma a'}\right) 100$$

where Σa is the sum of the lower dominance rank for species present in both regions, and $\Sigma a'$ is the maximum possible shared dominance (8 + 7 + 6. . . for grasses and for forbs = 72). The percentage of dominant graminoid and forb species common to both regions also was calculated (presence similarity).

A soil pit was dug at approximately the mid-slope position in each of the four undisturbed stands. Horizons were identified, and soil samples removed for laboratory analysis of organic matter, lime, texture, pH, conductivity and available NO_3-N, P, K and SO_4-S. Maximum thickness of samples from any part of the soil profile was 10 cm. Analyses were done by the Saskatchewan Soil Testing Laboratory, Saskatoon, Saskatchewan, using standard techniques. Inadvertent storage of the soil samples under warm, moist conditions for several weeks resulted in mineralization of much of the soil nitrogen, and probably explains the extremely high levels of NO_3-N observed, especially for surface horizons.

Classification of the soil profiles was done by W. W. Pettapiece, Agriculture Canada-Soil Survey, Edmonton, Alberta, using photographs and chemical analysis data. These should be considered preliminary, pending a comprehensive soil survey in WBNP.

Results and Discussion

Dry-Grassland Flora

A total of 71 species was collected at the four grassland sites (Appendix 1). Of this total, about 24% are at or near the northern limit of their ranges and are found mainly in the grasslands of the southern Prairie Provinces. Prominent among these are *Anemone cylindrica, Comandra umbellata, Geum triflorum, Helictotrichon hookeri, Silene drummondii, Monarda fistulosa, Poa arida, Stipa comata* and *S. curtiseta*.

Benchmark Creek Site

The stands sampled at this site were located on gentle south- and southwest-facing slopes near Benchmark Creek. The soil under the undisturbed vegetation was loamy near the surface, but with a heavy clay subsoil (Table 1). The top 18 cm were very high in organic matter and relatively fertile. The pH was low near the surface, but increased greatly with depth. Salts were present below about 40 cm, as evidenced by the increase in conductivity at that depth. This profile was classified as a Black Solod (W. W. Pettapiece, personal communication). The soil also has the character of an Orthic Black Chernozem, but does not fit the criterion of having a mean annual temperature above 0°C (D. W. Anderson, personal communication).

Dominant grasses at the Benchmark Creek site were *Stipa curtiseta* and *Danthonia californica* (Table 2). *Carex praticola* and *C. xerantica* also ranked high in cover. The most important forb was *Galium boreale*; however, several other species also were present. The relatively high shrub cover was contributed mainly by *Amelanchier alnifolia*.

TABLE 1. Classification and properties of soils sampled at four locations in Wood Buffalo National Park.

Location	Classification	Depth cm	Texture	Organic Matter %	Lime	pH	Cond. mS cm^{-1}	Available Nutrients NO_3-N	P ppm	K	SO_4-S
Benchmark	Block Solod	0-9	l	11.3	Abs	4.7	1.1	437	15	110	5
Creek		9-18	cl	5.1	Abs	5.8	0.2	8	3	30	19
		28-38	c	1.6	Abs	7.9	1.7	7	2	50	287
		43-53	c	0.6	Med	8.3	5.6	2	2	55	150
		55-65	c	0.5	Med	8.6	3.8	2	2	60	40
Salt River	Dark-Grey	0-10	l	7.1	Abs	5.0	0.6	132	37	380	19
	Solod	45-55	c	0.9	Low	8.5	0.8	4	3	75	17
Peace Point	Orthic Cumulic	5-15	sl	2.7	Low	7.9	0.3	35	4	45	7
	Regosol	45-55	sl	2.6	Low	7.7	0.3	6	3	60	40
		95-105	sl	2.7	Low	7.7	0.4	6	2	55	57
Peace	Humic	0-10	sl	5.4	High	7.4	1.0	225	8	190	4
Escarpment	Regosol	15-25	sl	1.5	High	7.9	0.2	9	2	80	7
		45-55	cl	0.8	High	7.9	0.2	3	2	100	5

At several places in this site, mid- and upper-slope positions were compacted and eroded down to the heavy clay subsoil. Although we have no direct evidence, this disturbance might have been caused by bison, which use this area. Vegetation in these compacted and eroded stands was dominated by *Koeleria macrantha* and *Carex obtusata*, along with the forbs *Geum triflorum, Solidago spathulata* and *Artemisia campestris* (Table 2). No shrubs were present in these stands. A distinctive glaucous type of *Agropyron trachycaulum* was present at this site and at disturbed sites sampled elsewhere in WBNP. Disturbance eliminated *Stipa curtiseta* and *Danthonia californica*, but increased weedy forbs like *Cerastium arvense* and *Artemisia campestris*.

Salt River Site

This site was located on a gentle south-facing slope of the bluff above the Salt River. The soil of this site was similar to the Benchmark Creek location; however, the organic matter content was somewhat lower and the color lighter, leading to classification as a Dark-Grey Solod (Table 1). Heavy-clay underlies the loam-textured upper horizons. Conductivity was low throughout the sampled part of the profile; salts may have been leached to greater depth. The pH increased from 5.0 in the upper horizon to 8.5 at depth. Available nutrient levels were relatively high.

Vegetation at this site was dominated by *Stipa curtiseta, Carex obtusata* and *C. siccata* (Table 2). *Solidago spathulata* and *Galium boreale* were the most important forbs. Shrub cover was less than at the Benchmark Creek site, and was made up predominantly of *Amelanchier alnifolia*.

Parts of the Salt River site were disturbed by vehicle traffic and bison activity. *Carex obtusata, C. siccata* and *Solidago spathulata* had high cover values in these stands (Table 2). Compacted and eroded locations had no *Stipa curtiseta* present, fewer shrubs and increased cover of *Artemisia frigida* and *A. campestris*. The glaucous taxon of *Agropyron trachycaulum* occurred only on the most disturbed sites. *Thalictrum venulosum* and *Vicia americana* were not present in the disturbed stands.

The undisturbed stands at Salt River contained species such as *Carex obtusata* and *Artemisia frigida*, suggesting that the entire site was more affected by disturbance than the Benchmark Creek location. The importance of *Carex obtusata, C. siccata* and *A. frigida* may also indicate that this site is drier; however, no data on soil moisture are available to support this idea.

Peace Point Site

The Peace Point site was on a relatively flat surface above the Peace River. The soil, an Orthic Cumulic Regosol, developed in glaciolacustrine sediments overlying Devonian gypsum. Flooding has not occurred in recent times, as evidenced by the lack of a cap of fluvial soil (Jeffrey 1961). Soil was sandy-loam textured. Chemical properties did not vary much throughout the profile (Table 1), with the exception of SO_4-S which increased, and NO_3-N, which decreased with depth. The soil was less fertile, and lower in organic matter than the previous two sites.

The undisturbed Peace Point site was strongly dominated by *Agropyron trachycaulum* var. *unilaterale* (Table 2). Three species of *Stipa* were important: *S. occidentalis, S. comata* and *S. curtiseta*. The forbs with highest cover were *Artemisia frigida,*

TABLE 2. Percentage cover of species sampled in undisturbed (U) and disturbed (D) stands of dry-grassland in Wood Buffalo National Park. Species are ranked by overall importance, based on cover and frequency.

	Benchmark Creek		Salt River		Peace Point		Peace Escarpment
Species	U	D	U	D	U	D	U
Grasses and Sedges							
Stipa curtiseta	5.3		5.9		1.4		24.7
Carex obtusata	0.8	1.9	7.5	8.5		10.4	
Agropyron trachycaulum var. *unilaterale*	1.6	1.3	0.7	2.2	20.8	0.1	0.1
Carex siccata			3.3	9.9	0.1		1.0
Koeleria macrantha	0.2	3.8	1.4	3.4	1.6	0.2	0.2
Danthonia californica	4.7		0.2	0.9			
Carex praticola and/or *Carex xerantica*	8.1	0.1		0.1			
Stipa columbiana					9.7		0.8
Poa glauca			0.2	0.1	0.7	3.4	
Festuca saximontana	0.2	0.1	0.3	0.1	0.7		
Agropyron trachycaulum var. *trachycaulum*		1.5		0.1		0.2	
Stipa comata					2.8	0.3	
Hierochloe odorata	1.4		0.1	0.1			
Schizachne purpurascens			1.9				
Forbs							
Solidago spathulata	0.9	3.1	11.9	5.6	0.1	1.1	
Artemisia frigida	1.2		1.3	5.5	5.2	20.2	1.0
Potentilla pensylvanica	0.1	0.2	0.6	1.4	3.9	22.3	0.1
Galium boreale	3.8	2.0	3.2	2.2	2.1	0.3	0.1
Geum triflorum	0.1	3.5	0.7	0.9		3.5	0.6
Erigeron glabellus	2.0	1.3	2.1	0.9	0.7		0.1
Achillea millefolium	1.6	1.6	0.4	1.2	0.8		0.1
Anemone patens	0.9		1.9	1.0	0.1	0.3	0.4
Vicia americana	0.7		0.1				3.5
Astragalus dasyglottis	0.3	1.6	0.1	0.1	0.1	0.1	0.5
Artemisia campestris	0.2	2.6		1.6			
Cerastium arvense	0.4	1.4	0.3	0.4			
Astragalus tenellus		0.1				1.1	2.0
Fragaria virginiana	0.2		0.6	0.1			0.3
Antennaria parvifolia	0.8	0.1	0.1	0.1			0.3
Smilacina stellata					0.1		1.8
Potentilla hippiana		1.4		0.1			
Thalictrum venulosum	0.1		1.5				
Linum lewisii	0.2	0.2	0.1	0.1			
Potentilla arguta	0.6		0.1	0.4			
Astragalus spp.						6.1	
Comandra umbellata					0.7		0.1
Shrubs							
Rosa woodsii	0.7		0.8	0.5	0.7		13.3
Amelanchier alnifolia	9.1		4.7				4.9
Symphoricarpos occidentalis	5.8		0.7		0.1		0.6
Arctostaphylos uva-ursi							2.9

TABLE 3. Comparisons of Wood Buffalo National Park grasslands with *Agropyron-Stipa* and *Stipa* faciations of Peace River grasslands (Moss 1952), based on (1) presence similarity and (2) dominance similarity (defined in text).

Community Faciation in Moss (1952)	Similarity Criterion	Benchmark Creek	Salt River	Peace Point	Peace Escarpment
	Presence	63	63	44	38
Agropyron-Stipa	Dominance	51	53	43	33
	Presence	50	50	56	38
Stipa	Dominance	35	42	47	46

Potentilla pensylvanica and *Galium boreale*. Shrubs were relatively unimportant at this site.

The disturbed stand was compacted and trampled by intermittent vehicle traffic and human activity. This caused the elimination of most of the *Stipa* and *Agropyron* cover, and an increase in the cover of *Carex obtusata, Poa glauca, Artemisia frigida, Potentilla pensylvanica* and *Geum triflorum* (Table 2). *Astragalus* species were prominent on the disturbed site.

Peace Escarpment Site

Approximately 1 km north of the Peace Point site is a steep, south-facing escarpment which rises about 15-20 m from bottom to top. The stands sampled on this slope were strongly dominated by *Stipa curtiseta* (Table 2). Several forbs were present, but they were less important than the shrubs *Rosa woodsii* and *Amelanchier alnifolia*. This site was relatively undisturbed.

The soil at this site was a Humic Regosol, which we interpret as having developed in till derived from limestone or dolomite bedrock. The texture was sandy-loam to clay-loam (Table 1) and stones were present. High levels of lime were present throughout the profile; pH was relatively high. Fertility was somewhat greater than in the Peace Point location.

Similarity to other Grasslands

The grasslands of WBNP are considered to be a northeastern extension of the Peace River grasslands (Raup 1935; Moss 1952; Wilkinson and Johnson 1983). We used similarity coefficients based on the dominant grasses, sedges and forbs to compare our sites with the *Stipa* and *Agropyron-Stipa* faciations in the Peace River region (Moss 1952). The Benchmark Creek and Salt River sites contained 63% of the dominant species present in the *Agropyron-Stipa* faciation of Moss (Table 3). The coefficients based on dominance rank showed 51 and 53% similarity of Benchmark Creek and Salt River sites to the *Agropyron-Stipa* faciation. These two sites were less similar to Moss's *Stipa* faciation. The Peace Point and Peace Escarpment sites showed less overall similarity to the Peace River grasslands; however, in both cases the greatest similarity was with Moss's *Stipa* faciation.

The *Agropyron-Stipa* faciation is described by Moss (1952) as occupying mesic sites, while the *Stipa* faciation occurs on drier sites. Our interpretation of the WBNP grasslands is similar: the Peace Point and Peace Escarpment grasslands are drier than the Benchmark Creek and Salt River communities. A similar separation of grassland types was followed by Wilkinson and Johnson (1983) in their description of the Peace River grasslands. Their grasslands also resemble those of WBNP in having an important *Carex* component.

Several species in the Peace River grasslands appear to be absent from WBNP. Among the most important of these are *Agropyron dasystachyum, Solidago missouriensis* and *Stipa viridula*. In contrast, *Stipa comata*, an important mixed grassland species, occurs in the Peace Point and Peace Escarpment sites, but is not a component of the Peace River grasslands of Moss (1952). Raup (1935) reported collecting *Agropyron smithii* in WBNP. However, we were unable to find this species at our sites. In southern grasslands, *A. smithii* is common on eroding heavy clay soils; this niche in WBNP appears to be filled by a glaucous type of *A. trachycaulum* (non-rhizomatous).

Environmental Relationships

Soil conditions may be the most important factor explaining the occurrence of grassland in the boreal forest zone. The Benchmark Creek and Salt River grasslands were found on solonetzic soils with a heavy clay subsoil. The relationship of this soil type to grassland distribution in the Peace River region was discussed by Moss (1952) and Wilkinson and Johnson (1983). In three of four profiles we found high sulfate levels at depth; these levels might have originated from the gypsiferous parent material of the soils. Raup (1935) observed that the distribution of what he called "prairies" (primarily non-saline and saline wetlands) in WBNP was correlated with poorly-drained clay soils of glaciolacustrine origin. The sometimes confusing use of the term "prairie" to refer to wetland vegetation has been pointed out by Rowe

and Coupland (1984). Our dry grasslands were found on sites which were non-saline, at least in the upper horizons, with relatively good surface drainage. For this reason we consider them to be true grasslands, distinct from the wetland "prairies" in WBNP.

Dry grasslands also can be found on non-solonetzic soils in WBNP, provided there is a relatively warm microclimate and good drainage, such as in the Peace Point and Peace Escarpment sites. These sites resemble the *Stipa* faciation of the Peace River grasslands; this faciation is reported to occur on warm, dry south-facing slopes (Moss 1952; Wilkinson and Johnson 1983). Fire may be a factor in reducing forest encroachment into this type of grassland (Jeffrey 1961). We observed further expansion of aspen into the mesic grassland at Peace Point since Jeffrey's study.

Bison grazing is considered by Soper (1941) to have had little impact on the vegetation of WBNP. Although he did find severe disturbance around watering areas, Soper concludes that ". . . the luxuriant abundance of forage keeps pace with, or far exceeds the rate of consumption." Bison use only a small proportion of the herbage available in *Carex atherodes* and *Calamogrostis* spp. meadows of the Slave River lowlands north of WBNP (Reynolds et al. 1978). The increases in *Carex obtusata, Koeleria macrantha* and *Artemisia* spp., and decrease in *Stipa curtiseta* which we observed on compacted and eroded sites at Salt River and Benchmark Creek are the same as those changes which Moss (1952) ascribed to heavy grazing by cattle in the Peace River district. This suggests to us that bison may have the potential to modify the dry grasslands in WBNP, although a comprehensive range survey would be necessary to document this.

Unfortunately the dry grasslands are not protected completely from human disturbance. The Peace Point site, within the national park, is threatened with obliteration by the settlement being developed there. Quarrying and vehicle traffic have drastically disturbed the Salt River site, which lies outside the WBNP boundary. Attempts need to be made to locate additional stands of this special vegetation type, and management plans should be developed to ensure the preservation of this unique feature of Wood Buffalo National Park.

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Appendix 1.

List of plant species collected in or adjacent to dry-grassland sites in Wood Buffalo National Park in July 1983. Specimens are in the W. P. Fraser Herbarium, University of Saskatchewan, Saskatoon. Taxa marked G have a distribution concentrated in the southern Prairie Provinces, as determined from range maps in Porsild and Cody (1980). NA means maps not present in Porsild and Cody (1980). Nomenclature follows Moss (1983).

Achillea millefolium
Agropyron trachycaulum var. *trachycaulum*
Agropyron trachycaulum var. *unilaterale*
Agrostis scabra
Amelanchier alnifolia

Appendix 1 *(Concluded).*

Androsace septentrionalis
Anemone canadensis
Anemone cylindrica NA, G
Anemone multifida
Anemone patens G
Antennaria parvifolia
Arabis divaricarpa
Arabis drummondii
Arctostaphylos uva-ursi
Artemisia campestris
Artemisia dracunculus
Artemisia frigida
Aster ciliolatus
Astragalus dasyglottis
Astragalus striatus
Astragalus tenellus
Calamagrostis stricta
Campanula rotundifolia
Carex obtusata
Carex praticola
Carex siccata NA
Carex xerantica NA
Cerastium arvense
Comandra umbellata G
Danthonia californica
Erigeron glabellus
Erysimum inconspicuum
Festuca saximontana
Fragaria virginiana
Galium boreale
Geum triflorum G
Helictotrichon hookeri G
Hierochloe odorata
Koeleria macrantha G
Lappula occidentalis
Lathyrus ochroleucus
Lepidium ramosissimum NA, G
Linum lewisii
Monarda fistulosa NA, G
Orthocarpus luteus G
Oxytropis splendens
Poa arida NA, G
Poa glauca
Poa juncifolia G
Poa nemoralis
Poa pratensis
Populus tremuloides
Potentilla arguta
Potentilla gracilis NA, G
Potentilla hippiana NA, G
Potentilla nivea
Potentilla pensylvanica
Ranunculus cardiophyllus NA
Rosa woodsii
Schizachne purpurascens
Silene drummondii G
Smilacina stellata
Solidago spathulata
Stellaria longipes
Stipa comata G
Stipa curtiseta G
Stipa columbiana NA
Stipa richardsonii G
Symphoricarpos occidentalis
Thalictrum venulosum
Vicia americana
Viola adunca

Effects of Harvesting Wild Rice, *Zizania aquatica*, on Soras, *Porzana carolina*

William A. Fannucchi,[1,2] Genevieve T. Fannucchi,[1,2] and Lyle E. Nauman[1]

[1]College of Natural Resources, University of Wisconsin, Stevens Point, Wisconsin 54481
[2]Present Address: Rt. 1, Box, 323H, Arena, Wisconsin 53503

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Sora, *Porzana carolina*, responses to Wild Rice, *Zizania aquatica* L. var. *interior* Fassett (*Z. palustris* var. *interior* (Fassett) Dore), harvesting were monitored during a two year study on a 59 ha marsh in Minnesota. Soras were evenly distributed between harvested and unharvested sections prior to rice harvesting. Sora numbers declined during rice harvesting on the harvested side while remaining the same or increasing on the unharvested side. Rice harvesting appeared to have a significant impact on Soras. The establishment of refuge areas within a lake may be useful in mitigating this impact.

Key Words: Wild Rice, *Zizania aquatica*, Sora, *Porzana carolina*, harvest impacts, Minnesota.

Many species of wildlife use Wild Rice, *Zizania aquatica* L. var. *interior* Fassett (*Z. palustris* var. *interior* (Fassett) Dore), beds (Bent 1926; Coulter 1957; Dore 1969; Kirby 1976; Peden 1977). In particular, Soras (*Porzana carolina*) may use these areas extensively during the fall (Walkinshaw 1940). Bent (1926) reported that Wild Rice is a favorite food of Soras and that they often leave their breeding marshes during the fall to occupy rice beds. Webster (1964) found that Wild Rice comprised 92% of the total food consumed by Soras in a tidal fresh marsh on the Housatonic River in Connecticut.

Man is also attracted to Wild Rice. Rice harvesting is a popular fall activity in Minnesota and Wisconsin. In 1979, 8430 licensed Minnesota harvesters collected 1.14 million kg of native Wild Rice, valued at $11.22 million, from 8100 ha of rice beds (Libertus 1981).

Although rice harvesting is generally considered to have little or no impact on wildlife populations, no studies have been conducted to support this contention. The loss of wetlands to human development combined with heavy local pressure from rice harvesters may limit the number of areas available to Soras for resting and feeding during migration. The purpose of this study was to determine the effects of harvesting on Soras using a Wild Rice bed.

Study Area

The study site, Lake Josephine, is a 59 ha shallow marsh in the Sherburne National Wildlife Refuge, Zimmerman, Minnesota (45° N, 93° W). The rice bed (14 ha) lies in the center of the marsh.

Methods

Rice densities were determined in July 1980 and 1981 with rectangular plots measuring 0.1 m^2 (Daubenmire 1959). Two sample plots were taken at 30 m intervals along 13 transects across the width of the marsh. Rice densities were mapped and the marsh was divided into two sections of approximately equal areas and rice densities. The eastern portion of the marsh was harvested while the west half was left undisturbed (Figure 1).

Experienced rice harvesters using traditional methods (Hofstrand 1970) harvested from 0900 to 1400 h with two to four day intervals between harvests. Six harvests were conducted from 29 August to 14 September 1980 and five were conducted from 1 to 15 September 1981. The number of rice boats used varied from 1 boat/1.9 ha to 1 boat/4.3 ha.

Soras were counted by mapping responses elicited either by taped play-back of Sora calls (Glahn 1974; Griese et al. 1980; Marion et al. 1981) and/or by three sharp raps against the sides of an aluminum canoe. Listening stations were located along the boundary between the harvested and unharvested sides, at 60 m intervals. Taped calls were played for 45 seconds. Three minutes were allowed after each playback or series of raps to record Sora responses. Only calls occurring within a 180° arc in front of the canoe were recorded.

The census of Soras began 26 August 1980 and 29 August 1981 and was conducted between 0800 and 1200 h. Subsequent censuses were conducted one to four days after a harvest and only when winds were < 8 km/hr. Two censuses were conducted in 1980 and eight in 1981. In addition to audio counts, two flush counts were conducted in 1981 using six transects established perpendicular to the harvest/non-harvest boundary at 120 m intervals. The number of Soras flushed and their distance when flushed were recorded.

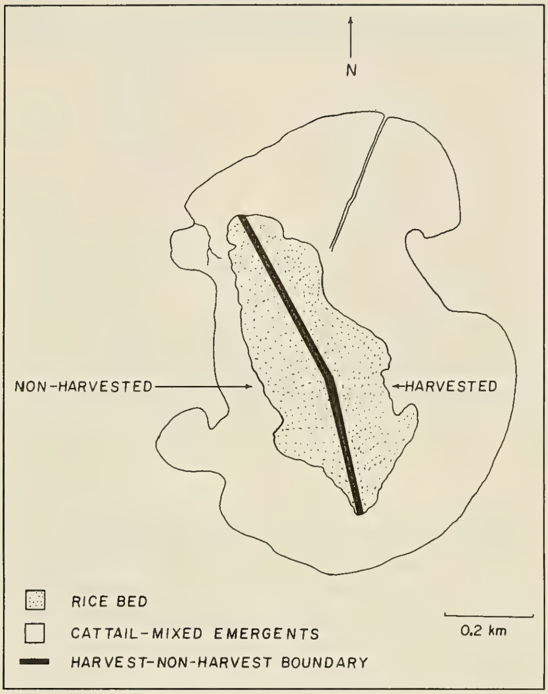

FIGURE 1. Location of the harvest/non-harvest sections on Lake Josephine, Sherburne National Wildlife Refuge, Zimmerman, Minnesota.

Results

The average rice density in Lake Josephine was 52 stems/m^2 in 1980 (N = 236; SD = 39) and 49 stems/m^2 in 1981 (N = 216; SD = 30). Soras responded more often to the loud noise created by rapping the sides of the canoe than to the taped calls. The use of taped calls was therefore discontinued.

Before the harvesting program in 1980, responding Soras were distributed evenly throughout the rice bed (Table 1). The first two harvests were conducted on 29 August and 1 September. A census conducted on 2 September showed a marked decrease in the number of responding Soras on the harvested section; the number of Soras on the unharvested side remained unchanged (Table 1).

The first pre-harvest census in 1981 again showed a nearly equal distribution of Soras. On 31 August, the second pre-harvest census showed a decline in the total number of Soras, possibly due to early migration. Tanner (1953) reported that decreases in Sora numbers in Iowa during August, followed by increases in mid-September, may have represented the departure and influx of migrants. Despite this decrease, the relative distribution between sides remained nearly equal.

The harvest attempted on 1 September 1981 proved to be premature. The rice was not yet ripe and the harvesters returned after less than 1 hour in the rice bed. The next census conducted on 5 September showed a slight increase in responding Soras and again nearly even distribution. After the first two full

TABLE 1. Number of responding Soras on the harvested and unharvested sides of Lake Joesphine during the 1980 and 1981 Wild Rice harvesting season on the Sherburne National Wildlife Refuge, Zimmerman, Minnesota.

		No. of Responding Rails			
		Harvested Area		Unharvested Area	
Date of Census	No. of Harvests Between Censuses	Audio Census	Flush Count	Audio Census	Flush Count
1980					
26 August	—	21	—	17	—
2 September	2	7	—	17	—
1981					
29 August	—	19	—	16	—
31	0	9	—	11	—
5 September	1	12	—	11	—
10	2	7	—	12	—
13	1	2	2	17	10
16	1	0	—	0	—
18	0	0	0	0	3
25	0	0	—	0	—

Harvest dates: 1980: 29 August, 1, 5, 8, 11, and 14 September.
1981: 1, 6, 8, 11, and 15 September.

harvests (6 and 8 September), however, the number of Soras in the harvested section began to decline and continued to decrease during the rice harvesting program. By 13 September, after three full harvests, the number of responding Soras on the harvested side had declined to 10% of the total while the number on the unharvested side increased (Table 1). A flush count was conducted on this date to determine whether Soras on the harvested side had merely stopped vocalizing in response to disturbance. Flush counts were not used prior to this time because such disturbance is very similar to that of rice harvesting and therefore could have masked the impact, if any, caused by the harvesters. Of twelve Soras flushed, only two were on the harvested side.

By 13 September, the number of responding Soras on the unharvested side had increased to the pre-harvest level recorded on 29 August. No birds responded from either side on 16 September, most likely due to low temperatures (3° C) on the night of 15-16 September. Soras are known to be sensitive to cold and will often leave an area at the first frost (Bent 1926; Walkinshaw 1940). On 18 September, another flush count detected three Soras, all from the unharvested side.

Discussion

Various methods have been used to calculate the number of Soras and related species. The use of taped calls to elicit responses has been used successfully, but with mixed results (Glahn 1974; Griese et al. 1980). During our late summer and fall censuses, Soras responded more readily to a loud noise (Gochfeld 1972) than to the taped calls. Marion et al. (1981) found the use of audio playbacks helpful in counting elusive birds such as the Sora; however, the highest densities in that study were found in the spring. Summer through winter densities were much lower. This decrease in density may have reflected an unwillingness to respond to taped calls rather than decreases in Sora densities. Griese et al. (1980) also found that Soras did not respond to taped calls in August and September.

The results suggest that Soras may be adversely affected by rice harvesting. Although harvesting was limited to four hours/day with at least two-day intervals between harvests, the effect appeared to be severe. Sora numbers on the harvested and unharvested areas were not significantly different before the harvest. However, decreases were observed in both years on the harvested area during the harvesting season, while the number of Soras on the unharvested side remained the same or increased. The call count conducted on 13 September 1981 showed the number of Soras on the harvested side to be significantly lower than the number on the unharvested side ($P \leq 0.05$).

The establishment of unharvested areas in rice beds may be useful in mitigating the effects of rice harvesting. The increase in the number of Soras in the unharvested area on 13 September may have been due to the shifting of birds from the harvested side to the undisturbed area. However, they may have been migrants that selected the unharvested side because of the greater availability of rice. In either case the unharvested section provided potentially valuable habitat for a longer period of time. Since the timing of rice maturation varies with the weather and differs from year to year, the presence of refuge areas may significantly increase resources available to both local and migrant populations of Soras.

Acknowledgments

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Life History Traits of the Meadow Jumping Mouse, *Zapus hudsonius*, in Southern Ontario

JAMES A. HOYLE and RUDY BOONSTRA

Division of Life Sciences, Scarborough Campus, University of Toronto, West Hill, Ontario M1C 1A4

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An Ontario population of *Zapus hudsonius* was live-trapped from 1978 to 1982. The active season was approximately 18 weeks long, with males emerging from hibernation two weeks before females in early May and entering into hibernation two to four weeks before females in late August or early September. Old individuals entered before young. Although reproductive activity occurred throughout the active season, females were never observed to be lactating or pregnant more than once in a given year. Overwinter weight loss was similar in males (36.8%) and females (34.5%), but overwinter survival appeared higher in males (39%) than in females (18%). Of the 208 individuals caught, six lived at least three years. Our data show a population of *Z. hudsonius* in southern Ontario with a shorter active season but greater longevity than has been reported for more southern populations.

Key Words: Meadow Jumping Mouse, *Zapus hudsonius*, life history, demography, active season, hibernation, survival, longevity, Ontario.

The Meadow Jumping Mouse, *Zapus hudsonius*, is widely distributed throughout central and southern Canada and the northeastern United States where it generally inhabits moist grassland (Banfield 1974). In the United States, it has been the subject of several natural history (Quimby 1951; Whitaker 1963, 1972) and two recent demographic studies (Nichols and Conley 1982; Adler et al. 1984), but no studies have been carried out in Canada.

In the present study we describe some life history and demographic parameters from a population of *Z. hudsonius* over a five-year period in southern Ontario. Long-term studies are esssential for making demographic comparisons among small mammal species (French et al. 1975; Kirkland and Kirkland 1979; Cranford 1983). As such, our data may help to elucidate some of the selective forces acting to shape life history patterns in this species.

Study Area and Methods

The study was carried out between July 1978 and May 1982 on a 10 ha abandoned pasture located 30 km north of Toronto (for an aerial picture of the area, see Figure 1 in Boonstra and Hoyle 1986). The vegetation cover was dominated by over 60% grasses with the major species being *Agropyron repens* (Couch grass), *Poa pratensis* (Kentucky Bluegrass), *Dactylis glomerata* (Orchard grass), and *Phleum pratense* (Timothy). Major herb species were *Cirsium arvense* (Canada Thistle), *Lotus corniculatus* (Birdsfoot Trefoil), and *Vicia cracca* (Tufted Vetch). Though the grass was not cut during our study, it had previously been cut annually.

The area contained five live-trapping grids, each of which was divided into a checkerboard of points spaced 7.6 m apart. One Longworth live trap was placed at each point and baited with whole oats; cotton nesting material was provided for warmth. Three of the grids were square (A,B,E) and two were irregular (C,D); four contained 100 trap points (A,B,C,E) and one contained 98 (D). Fifty extra traps were placed on grid A as small mammal densities increased. Traps were left permanently on the grids and were covered with a board or snow shelter (Pruitt 1959; Iverson and Turner 1969). Traps were set every second week in the afternoon, checked the following morning and afternoon, and again on the second morning, when they were locked open. During the summer, traps were set only in the evenings to avoid mortality during the heat of the day.

Five other small mammal species were caught on the grids and are listed in order of decreasing abundance: *Microtus pennsylvanicus* (Meadow Vole), *Blarina brevicauda* (Short-tailed Shrew), *Peromyscus leucopus* (White-footed Mouse), *Mus musculus* (House Mouse), and *Sorex cinereus* (Masked Shrew). In a concurrent study, the *Microtus* population was manipulated in the following manner: grids A and B were live-trapped, grid C continuously had all breeding females removed, grid D continuously had all breeding males removed, and grid E was a total-removal grid. Onto grids B, C, D, and E during 1978, 1979, and 1980, small cohorts of young *Microtus* (approximately 20 animals each) were periodically introduced and later removed. Grids A and E were trapped throughout the active season of *Z.*

hudsonius in all years, but grids B, C, and D were trapped from late spring to mid-fall from 1978 to 1980 (for details see Boonstra and Hoyle 1986).

All *Z. hudsonius* were ear-tagged and on each capture the following data were recorded: tag number, trap location, body weight, sex, and sexual conditon. Sexual condition in females was determined visually by the presence or absence of lactational tissue and by obvious pregnancy. No reproductive data are presented for males because we could not accurately determine when an animal was scrotal. From autopsy samples, Whitaker (1963) found that there was only a 1 mm difference in testes size between males that were in reproductive condition and those that were not. All animals caught before July were classified as adults. Thereafter we used the classification of Whitaker (1963) to distinguish between age classes (juveniles < 13 g, subadults 13-14 g, adults > 14 g).

Population parameters were estimated by total enumeration methods (Krebs 1966) and we realize that these are consistent underestimations of true values. We were not able to use Jolly-Seber methods of population estimation because of poor trappability. Of the 208 individuals caught, 63% were caught only once. Of the individuals caught more than once on a grid, the minimum trappability estimate (Krebs and Boonstra 1984) per year on grids C, D, and E (numbers on A and B were too low) during 1979 and 1980 (1978 and 1982 were ignored as trapping occurred during only a portion of the trapping season) was also low, ranging from 0 to 21% in males and 0 to 36% in females.

We examined for differences in demographic parameters such as survival, growth rates, and movements among grids. No significant differences were found, except for density, because of high within-grid variation. For the results presented here, data from all grids were pooled unless otherwise stated. Details of the causes for differences in density between grids are reported in Boonstra and Hoyle (1986). Data for all years were pooled when differences between years were not significant.

Results

Active Season and Hibernation Patterns

The distribution of captures throughout the active season was not uniform but typically peaked in spring, before the young were born, decreased during summer, and increased to a lower peak in fall (Figure 1). We examined how the dates of emergence from hibernation (date of first appearance in the traps) and entry into hibernation (date of last appearance in the traps) varied among years and between sexes. Since we trapped every two weeks, the dates are only approximate. Dates of emergence varied by no more than two weeks between years for both sexes. Males emerged in late April or in the first two weeks of May; females emerged in the last two weeks of May (Table 1). Note that in 1980, although both sexes were first seen on 15 May, 83% were males. Thus the asynchrony in emergence patterns between the sexes was still evident that year. Males generally entered hibernation around 20 August, except in 1979, when some were still active until mid-September; females entered hibernation from mid-September to mid-October. The active season lasted about 17 weeks for males and 19 weeks for females.

We divided the animals into two classes: 'old' animals (those caught before 31 July, prior to the appearance of young animals in the traps); and 'young' animals (those caught for the first time after 31 July). Old males were always the first to enter into hibernation and none were caught after 24 August of any year. Old females disappeared by 7 September (with the exception of one caught on 16 October 1980 at 11 g), followed by young males, and finally by young females. Though last capture dates overlapped somewhat between young males and young females, in every year a young female was the last young animal to be caught in the fall.

Sex Ratio

We calculated the sex ratio of *Z. hudsonius* by two methods: first by the proportion of males caught within a trapping session; and second, by the proportion of males of the minimum number known to be alive during the same trapping session. The latter includes both those animals caught in the trapping session and those not caught but known to be alive because of captures before and after the trapping session. The proportion of males caught declined from 1.00 in May to 0.35-0.45 in mid-summer and finally to 0.00 in September (Table 2). This reflects asynchrony between the sexes in emergence from and entry into hibernation. From the minimum number known to be alive (Table 2), there were three periods when the sex ratio deviated significantly from 1 : 1. Sex ratio favoured males in May but favoured females in the latter part of June. Of the 208 different individuals caught, 98 were males ($\chi^2 = 0.35$, N.S.).

Movements

We calculated three indices of movement: 1) within-period movements were those occurring between successive captures in a trapping period on the same grid; 2) between-period movements were those occurring between the first capture in one trapping period and the first capture in the next trapping period on the same grid; and 3) between-grid movements were those occurring between grids within and between years.

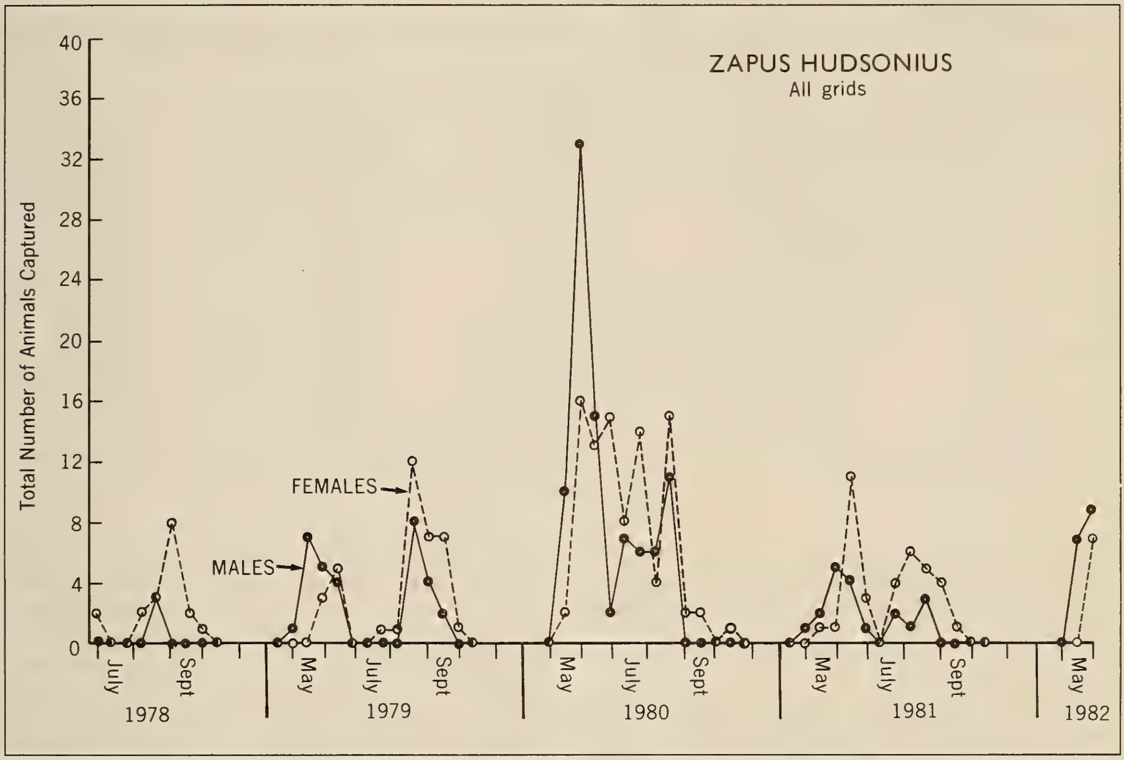

FIGURE 1. The total number of *Z. hudsonius* caught on the study area.

As there was a great deal of variation between animals, we found no significant differences in within-grid movements either within or between sampling periods or between sexes (males: within-periods mean = 17.0 m $\pm$ 2.2 ($\pm$1 SE), N = 31, between periods mean =25.5 m $\pm$ 2.7, N = 24; females: within-periods mean = 18.1 m $\pm$ 2.3, N = 31, between periods mean = 21.5 m $\pm$ 1.9, N = 37). We found no clear seasonal patterns in the mean distances moved.

Between-grid movements were calculated as the minimum distance between first capture points on the two grids. Males moved an average of 96.1 m ($\pm$ 12.5, N= 3) within a year and 125.9 m ($\pm$ 19.8, N = 10) between years. Females moved an average of 129.2 m

TABLE 1. Dates of emergence from and entry into hibernation for *Z. hudsonius*.

	Emergence		Entry	
Year	Males	Females	Males	Females
1978	—	—	22 August	5 October
1979	3 May	31 May	20 September[1]	4 October
1980	15 May	15 May[2]	21 August	16 October
1981	30 April	14 May	20 August	17 September
1982	13 May	27 May	—	—

[1] 8 females and 2 males.
[2] 2 females and 10 males.

TABLE 2. Sex ratio (proportion male) and survival of *Z. hudsonius*. Sample sizes in parentheses. *Chi square test statistic shows significant deviation from 50:50 sex ratio at 5% level.

Month	Sex Ratio Based on: Minimum Number Alive	Number Caught	Minimum Survival Rate[1] Male	Female
May	0.52 (54)	1.00 (2)	0.00 (2)	— (0)
	0.66* (70)	0.90 (29)	0.47 (17)	0.50 (2)
	0.60* (104)	0.65 (79)	0.43 (42)	0.63 (19)
June	0.48 (85)	0.46 (50)	0.39 (23)	0.50 (26)
	0.39* (75)	0.13 (23)	0.33 (3)	0.53 (19)
July	0.44 (68)	0.47 (15)	0.71 (7)	0.63 (8)
	0.41 (70)	0.42 (27)	0.57 (7)	0.44 (18)
	0.48 (54)	0.35 (20)	0.71 (7)	0.31 (13)
August	0.44 (86)	0.42 (60)	0.48 (25)	0.47 (34)
	0.46 (67)	0.17 (24)	0.25 (4)	0.17 (18)
September	0.46 (61)	0.14 (14)	1.00 (1)	0.17 (12)
	0.52 (52)	0.00 (2)	— (0)	0.58 (2)

[1] juveniles excluded.

(± 17.0, N = 6) within a year and 121.2 m (± 14.6, N = 4) between years. The maximum distances moved for males and females were 288 m and 169 m, respectively.

Reproduction

Pregnant females were caught between 9 June, when 30% (N = 27) were pregnant, and 5 September, when 11% (N = 9) were pregnant. Lactating females were caught only during the same time interval. No female was found to be pregnant or lactating more than once in a single active season. Fewer females were lactating from mid-June to mid-July (18.9%, N = 53) than from mid-July to the third week in August (38.5%, N = 65). Both our pregnancy and lactation rates are likely to be underestimates, as they relied solely on external examination.

Body Weight Dynamics

The mean body weight of adult males decreased in May, remained low until the end of June, and increased by about 6 g in late August (Figure 2). Body weight fell in September as old animals entered into hibernation, leaving young low-weight males. Adult females (obviously pregnant females were excluded) showed the same general trend, though their weight increased in mid-June, stabilized in July, and then increased rapidly in August and the first week in September. Mean adult body weight was consistently higher for females than males.

Absolute growth rates (g/day) were calculated for all adult animals caught in two successive trapping periods. In May, the one female caught more than once lost weight (-0.140 g/day), while the males gained weight (mean = 0.035 ± 0.020 (± 1 SE), N = 4). From June to the third week in August, both sexes showed positive growth rates (males: mean = 0.150 ± 0.033, N = 19; females: mean = 0.150 ± 0.038, N = 17). From late August to September, only female individuals were caught more than once and they showed an even higher growth rate (mean = 0.253 ± 0.099, N = 8). The few subadults (both sexes pooled) caught over the entire season showed growth rates comparable to that of adults in summer (mean = 0.144 ± 0.082, N = 5).

Weight loss during hibernation was calculated for all animals caught in late summer or fall of one year and then recaptured in the spring of the next year. Males lost an average of 36.8% (± 3.5, N = 6, range 23-46%) of their body weight, while females lost 34.5% (± 5.5, N = 7, range 10-52%). These values probably underestimate the true value since our trapping schedule did not allow for capture of animals immediately before entering hibernation (when body weight should be maximal) or just after they emerged (when body weight should be minimal).

Survival

Minimum survival rates were calculated between each pair of trapping sessions and include two components – death and emigration – which cannot be separated by our trapping methods. To allow comparison with Nichols and Conley (1982), we pooled the survival of adults and subadults. Juvenile survival was ignored, as only five were caught. The analysis examined whether animals were caught anywhere on the study area. We found no differences between or within sexes between a May-June or July

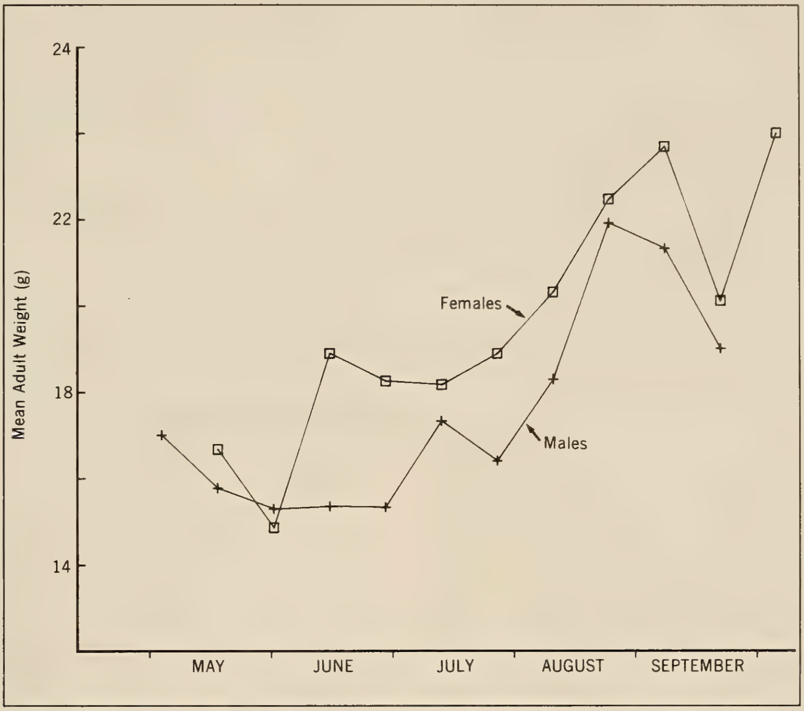

FIGURE 2. Mean weekly body weights of adult *Z. hudsonius*. Pregnant females were excluded.

period (Table 2). Since our survival rates do measure whether an animal alive in the fall reappears the next spring, the low survival rates seen in late August and September suggest high overwinter losses. An estimate of overwinter survival was determined by calculating the proportion of those animals caught in the last week of August or later in the fall that were caught at some future time. More males (39%, N = 23) than females (18%, N = 18) survived the winter, but this difference is not significant (χ^2 = 1.84).

For all animals caught in more than one trapping session, we calculated a survivorship curve and an expectation of further life (Leslie et al. 1955) for each sex. Males had an average life expectancy that was eight weeks longer than females. Three successive plateaus occurred in females and two in males, corresponding to overwinter periods. Approximately 60% of the males lived one year and 20% lived two years, compared with 40% and 10%, respectively, of the females (Figure 3).

Animals were inferred to have been at least one year old if they were caught for the first time in the spring before breeding had occurred and thus must have been born sometime previously. Six individuals, two males and four females, lived through at least three winters and hence were approximately three years old. Two of these females were caught only twice: one was caught on 22 September 1978 and again on 25 June 1981 on grid A; and one was caught on 14 June 1979 on grid D and again on 25 June 1981 on grid E.

Discussion

This study's regular trapping regime and high densities over five years allowed for a more detailed picture of the demography of *Z. hudsonius* than has previously been reported. Adler et al. (1984) also trapped for five years, but they had very low densities (3-7.5 per ha) and only 11 animals were caught more than once. However, the major problem that has plagued all studies, including ours, is low trappability. As a result, data from the various grids were pooled. We recognize that differences may have occurred between years and grids, but because of low sample size and high variation, we were not able to detect these differences. Hence, though our pooling of data may have increased the noise somewhat, we believe

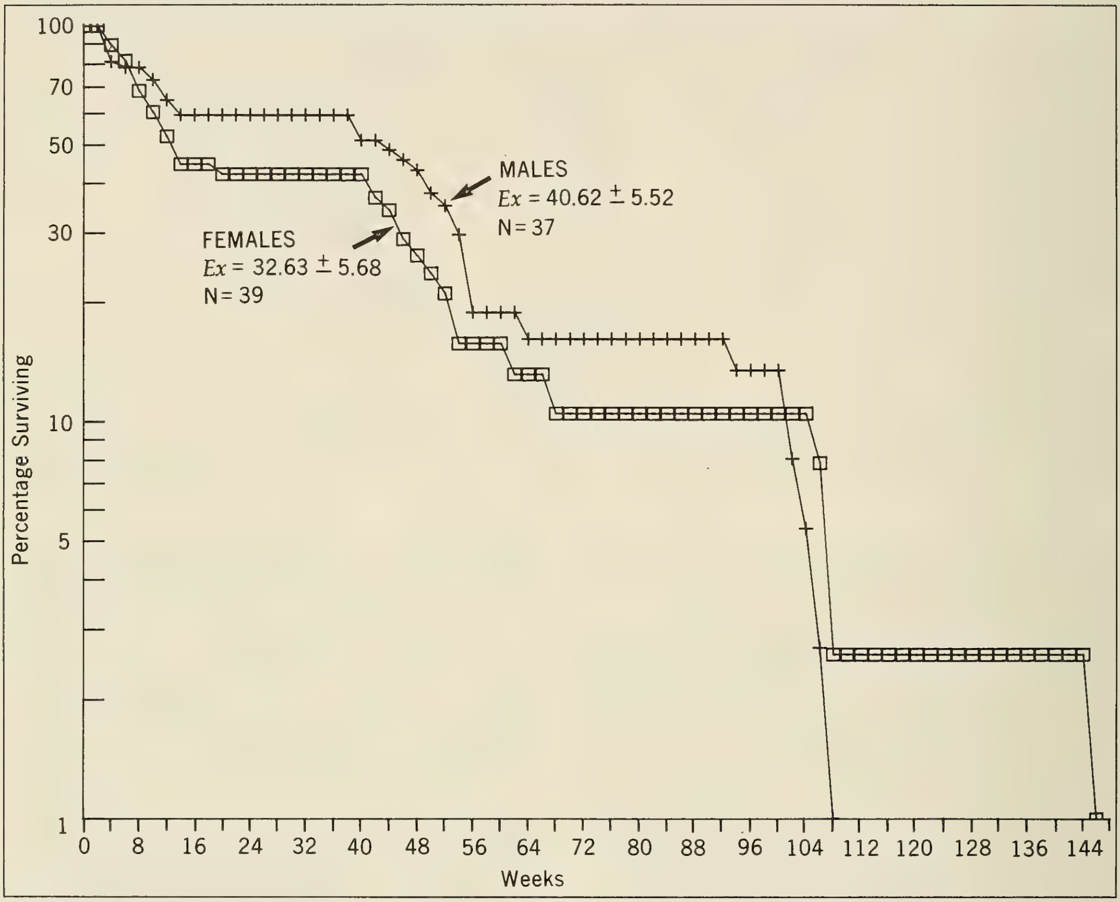

FIGURE 3. Male and female survivorship curves of *Z. hudsonius* for all animals caught more than once on the study area and their life expectancy (*Ex*) ± 1 SE.

the broad picture of *Z. hudsonius* demography is correct.

We found that males preceded females in emergence dates by about two weeks (Table 1). Michener (1983) suggested that a similar pattern in Richardson's Ground Squirrels (*Spermophilus richardsonii richardsonii*) was related to competition for mates. In these ground squirrels, females mate soon (1-4 days) after emerging from hibernation. Thus, males which had emerged after most females had reduced opportunity to mate. Cranford (1983) reported that male *Z. princeps* (Western Jumping Mouse) preceded females in emergence (3-9 days) only at altitudes above 2200 m, whereas at lower elevations both sexes emerged synchronously. Cranford (1983) found that both sexes were in breeding condition at emergence in late spring years. Whitaker (1963) reported that *Z. hudsonius* were in good condition and ready to breed immediately after hibernation. Female emergence time may be more subject to selection by environmental factors which influence their survival and that of their offspring (Michener 1983). Such selection would favour continued hibernation until environmental conditions are optimal.

We also found males to precede females in entry into hibernation, with old animals entering hibernation before young. Michener (1983) reported a similar pattern for Richardson's Ground Squirrels, except that young males entered hibernation after young females. Entry dates may be dictated by critical fat accumulation (see Whitaker 1963; Collins and

Cameron 1984) and this would account for differences between the age classes and the sexes. Females may enter later because they are suckling young into the late summer and must then obtain sufficient energy reserves to overwinter. This may put them at a disadvantage and in our study females showed lower overwinter survival rates than males (Table 2, cf. Cranford 1983).

Nichols and Conley (1982) found mean within-grid movements for *Z. hudsonius* to be smaller during the pre-hibernation period than during the spring-summer period. We examined our data for such differences but found no such seasonal trend, though our sample sizes were similar to theirs. Quimby (1951) reported home range sizes that were significantly larger for males than females. We could detect no differences between the mean distances moved for males and females. Movements between grids occurred relatively frequently. In addition to this, maximum distances moved would suggest *Z. hudsonius* to be capable of long distance movements. Adler et al. (1984) reported that their population of *Z. hudsonius* showed a high rate of 'transiency'.

Breeding probably occurs soon after emergence (see earlier discussion). Two breeding peaks have been reported in populations in New York (Whitaker 1963) and Michigan (Nichols and Conley 1982). Whitaker (1963) believed that individual females have two litters per year and Nichols and Conley (1982) have documented this. Nichols and Conley (1982) also found young females breeding in their first summer. External examination of live mice provided no evidence of individuals having two litters per year in southern Ontario, though reproductive activity occurs throughout the active season. However, low trappabilities lowered our ability to detect multiple lactations.

Body weight decreased following emergence in the spring. This is presumably a stressful time because reproductive activity commences, high quality food may be in short supply, and activity levels are high as indicated by high frequencies of capture at this time. Thereafter, weight increased gradually through the summer and then quickly just before hibernation. Mean adult body weight of females was consistently higher than males (Figure 2) and Nichols and Conley (1982) found a similar pattern. Just before hibernation the animals gained approximately one third of adult body weight (6 g). This figure corresponds closely to our calculated overwinter weight loss of 35%.

We found an overwinter mortality of approximately 75% which is similar to the 67% found by Whitaker (1963). Cranford (1983) reported overwinter losses of 25% in adults and 40-70% in juveniles for *Z. princeps*. As a result, longevity in *Z. hudsonius* is generally shorter (< 36 months) than that of *Z. princeps* (> 36 months). Cranford (1983) suggested that the shorter life span in *Z. hudsonius* was related to a longer active season, though our data suggest these differences in life span are a result of much higher mortality rates during hibernation rather than during the active season. We found the active season to be about 18 weeks in *Z. hudsonius* compared with 12 weeks in *Z. princeps*. Farther south, the active season of *Z. hudsonius* is even longer (22 weeks, Whitaker 1963). We found individual *Z. hudsonius* living for at least three years in southern Ontario compared with two years in more southern populations (Whitaker 1963). We would predict that populations farther north would show shorter active seasons and longer life spans comparable to those found in the high altitude populations of *Z. princeps* (Cranford 1983).

Zapus hudsonius is considered a relatively K-selected species exhibiting low densities, low reproductive potential, and high survival rates (French et al. 1975; Adler et al. 1984; but see Nichols and Conley 1983). The ultimate objective of making life history comparisons is to elucidate the important selective factors which shape life history strategies. The relative importance of *Microtus pennsylvanicus* (Meadow Vole) as a major competitor species shaping the life history of *Z. hudsonius* has largely been ignored, even though both have virtually identical distributions over North America and both live in moist meadows. Boonstra and Hoyle (1986) found an inverse relationship between *M. pennsylvanicus* and *Z. hudsonius* densities and concluded that the low *Z. hudsonius* densities found in almost all studies are a direct result of competition with *Microtus*.

Though we now have a rough picture of the long term demography of *Z. hudsonius*, many of the details about the social structure, breeding system, and population regulatory mechanisms are unclear. A major problem is still low trappability in almost all studies. We suggest that future research investigate the causes for this and means of improving it. In addition, techniques such as radiotelemetry and analyses of maternity and paternity are needed to understand this widespread but rare mammal.

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Seasonal Changes in Plumage Structure and Body Composition of the American Goldfinch, *Carduelis tristis*

ALEX L. A. MIDDLETON

Department of Zoology, University of Guelph, Guelph, Ontario N1G 2W1

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In American Goldfinches (*Carduelis tristis*), winter (basic) plumage was heavier ($P < 0.001$) than the summer (alternate) plumage; winter feathers had a greater percentage of plumulaceous barbules than equivalent summer feathers ($P < 0.001$) and had more barbules/barb ($P < 0.05$). Body fat levels were high in January and February and declined through May. Body water was low in winter but rose significantly ($P < 0.05$) in March coincident with the start of prenuptial (prealternate) molt. The lean dry component declined significantly ($P < 0.05$) between February and May. The postnuptial (prebasic) molt appears to be essential for providing a dense winter plumage, and the physiological processes related to molt may also be important in inducing other metabolic changes essential for over-winter survival.

Key Words: American Goldfinch, *Carduelis tristis*, plumage structure, body composition, seasonal changes.

The American Goldfinch (*Carduelis tristis*) is well adapted to survive the winter conditions characteristic of northern parts of its range. This adaptability results from a combination of metabolic processes (Dawson and Carey 1976; Carey et al. 1978), and environmental sensitivity (Middleton 1977a, 1982). However, plumage and molt have been ascribed minor roles in winter survival (Dawson and Carey 1976).

This finch is unique among carduelines because it undergoes two body molts yearly (Newton 1972; Middleton 1977b) and both molts are protracted (Middleton 1978). Previously it was suggested that the existence of a prenuptial (prealternate) molt might be essential to the production of a less dense summer plumage (Middleton 1977b), and the physiological processes associated with molt might have a profound influence on the timing of other events of the annual cycle (Middleton 1978).

The present study attempted to determine if differences existed between summer (alternate) and winter (basic) plumages of the American Goldfinch. Changes in body composition during the annual cycle were then compared to the timing of molt to determine if any relationship was apparent.

Methods and Materials

Plumage

Within one-week periods in early December 1976 and June 1977, male and female American Goldfinches were collected from Potter traps and mist nets at Guelph, Ontario. These periods were selected because they followed the peak molt periods (Middleton 1977b) and thus birds should have had plumage in new, unabraded condition.

Birds were immediately killed by cervical dislocation and their fresh weights recorded. Each specimen was then plucked and its remiges and rectrices separated from the remaining contour feathers. The entire plumage was weighed, oven-dried at 80° C for 24 h (Newton 1968) and the body feathers and flight feathers weighed separately. Plumage was placed in the oven for an additional 2 h and reweighed to check that all moisture had been removed. The average of the two weighings was recorded as the dry weight of the plumage. Weights were measured to the nearest 0.0001 g on an Oertling R20 balance. Finally, the total number of contour feathers on four goldfinches (one male and one female each in winter and summer plumage respectively) used previously in the analysis of feather weight were counted.

In December 1978 and June 1979, single feathers were plucked from the middle of the dorsal tract (anterior point of synsacrum) and the middle of the left ventral tract (posterior edge of sternum) of ten first year male American Goldfinches (Middleton 1974) trapped for banding (N = 20). This was done in an attempt to obtain equivalent feathers from winter and summer plumages of birds of known age and sex. The feathers from eight summer and eight winter birds were individually placed on microscope slides, mounted in DPX medium and covered with #1 coverslips. The length of each feather was measured. Under microscopic examination, the total number of barbs and the ratio of plumulaceous to non-plumulaceous barbs was calculated. The number of barbules on the first non-plumulaceous barbs of the vane (convex side) was also counted. The rationale for this procedure was that it provided an unambiguous reference point for comparison between equivalent barbs. If differences were detected here, they would

presumably be representative of changes in other parts of the feather. The back and breast feathers from the remaining four birds were examined by means of a scanning electron microscope (J.E.O.L. 35C).

Carcass Constituents

Between January and May 1977, American Goldfinches of both sexes were collected during a one week period at the mid-point of each month. Collection of specimens for body analyses was discontinued when knowledge of Carey et al.'s (1978) work was received (W. R. Dawson, personal communication). All birds were killed by cervical dislocation, their oesophagi, proventriculi and ventriculi opened, and all food was removed. Carcasses, including feathers, were weighed (fresh weight), freeze-dried for approximately 72 h, and the freeze-dried weights were recorded. Carcasses were then ground to a homogeneous consistency in an automatic mortar and pestle, while maintained in a frozen state by liquid nitrogen. From each carcass, two 1.0 g samples were placed in seamless fat extraction thimbles. Lipid was extracted with diethyl ether for 24 h in a Soxhlet apparatus. Following extraction, the fat-containing flasks were placed in a drying oven set at 100°C for 1 h and then in a glass desiccator to cool for 15 min. The flask with its extract was then weighed and the weight of the extract calculated by subtracting the original weight of the flask. Percentage fat was calculated for the sample and the average of the two values was taken as representative of the specimen. If the percent fat content varied by >1.5% between samples of the same bird, a third 1.0 g sample was processed. The mean of all three readings was then used. The weight of fat was subtracted from the freeze dried weight to give the lean dry weight. All measurements were made to the nearest 0.0001 g on an Oertling R20 balance.

Results

Plumage

The numbers of feathers counted for the winter male and female were 2931 and 2873, and for the summer male and female, 2938 and 3073, respectively.

For both sexes the entire winter (basic) plumage was heavier (Student's t-test) than the summer (alternate) plumage (Table 1). Likewise, with flight feathers removed, the dried winter body plumage was markedly heavier than the summer body plumage and provided a greater percentage of the total plumage weight. By contrast, weights of dried flight feathers did not differ between winter and summer.

Microscopic examination showed no significant differences between feather length and number of barbs on feathers from winter and summer plumages (Table 2). However, the percentage of plumulaceous barbs per feather was significantly (arcsin transformation) greater (Table 2) for both categories of winter feathers. Winter feathers had a greater number of barbules/barb than equivalent summer feathers (Table 2). Despite the difference in gross structure, electron microscopy revealed no differences in the fine architecture (e.g. shape and number of hamuli) of the feathers.

Carcass Constituents

The various body components were generally heavier in males than females (Table 3), but the seasonal trends were identical for both sexes (ANOVA). The lean dry constituent remained relatively high in January and February, then declined significantly (ANOVA and Duncan's multiple range test) between each of February and March and March and April. Fat was heaviest in January and February, then declined in March and remained relatively low thereafter. By contrast, body water decreased significantly between January and February, then

TABLE 1. Mean (± SE) weight of winter and summer plumages of American Goldfinches.

Sex	N	Fresh Body Weight (g)	Fresh Plumage Weight (g)	Dried Plumage Weight (g)	Dried Flight Feathers Weight (g)	Dried Flight Feathers % of Plumage	Dried Body Feathers Weight (g)	Dried Body Feathers % of Plumage
Winter								
♂	16	14.04 ± 0.193[1]	1.05 ± 0.021	0.96 ± 0.020	0.27 ± 0.005[5]	28.1	0.69 ± 0.019[3]	71.9
♀	10	13.88 ± 0.214[2]	1.00 ± 0.018	0.92 ± 0.028	0.24 ± 0.005[6]	26.1	0.68 ± 0.029[4]	73.9
Summer								
♂	9	11.91 ± 0.147[1]	0.86 ± 0.013	0.66 ± 0.015	0.26 ± 0.006[5]	39.4	0.40 ± 0.011[3]	60.6
♀	9	11.96 ± 0.140[2]	0.93 ± 0.034	0.64 ± 0.035	0.23 ± 0.005[6]	35.9	0.41 ± 0.022[4]	64.1

[1-4]Differences significant (P < 0.001).
[5,6]Differences not significant (P > 0.05).

TABLE 2. Mean (± SE) length, numbers of barbs and barbules, and ratio of plumulaceous to non-plumulaceous barbs of feathers from first-year male American Goldfinches.

Location	N	Length (mm)	No. of Barbs/mm Feather	No. Barbules/ 0.1 mm Barb	% Plumulaceous Barbs
Winter					
Back	8	20.3 ± 0.44[1]	4.3 ± 0.15[3]	4.4 ± 0.25[7]	75.7 ± 2.45[5]
Breast	8	17.4 ± 1.42[2]	4.4 ± 0.17[4]	4.7 ± 0.33[8]	72.8 ± 1.12[6]
Summer					
Back	8	19.4 ± 0.86[1]	4.0 ± 0.19[3]	3.7 ± 0.13[7]	63.4 ± 1.03[5]
Breast	8	17.9 ± 0.71[2]	4.3 ± 0.23[4]	4.1 ± 0.13[8]	50.2 ± 1.84[6]

[1-4]Differences not significant ($P > 0.05$).
[5,6]Differences significant ($P < 0.001$; arcsin transformation).
[7,8]Differences significant ($P < 0.05$).

TABLE 3. Mean (± SE) weight and percentage composition of body components from American Goldfinches.

Month	N	Total Fresh Weight (g)	Lean Dry Weight (g)	Lean % Total Body Weight	Fat Weight (g)	Fat % Total Body Weight	Water Weight (g)	Water % Total Body Weight
Male								
January	5	15.80 ± 0.711	5.23 ± 0.417	33.1	1.97 ± 0.278	12.5	8.60 ± 0.265[5]	54.4
February	10	14.70 ± 0.223	5.39 ± 0.236[1]	36.6	1.76 ± 0.143[3]	12.0	7.56 ± 0.263[5,6]	51.4
March	6	13.87 ± 0.156	4.55 ± 0.076[1]	32.8	0.89 ± 0.104[3]	6.4	8.43 ± 0.149[6]	60.8
April	10	14.03 ± 0.203	4.34 ± 0.082	30.9	0.83 ± 0.060	5.9	8.86 ± 0.124	63.2
May	2	13.56 ± 0.595	4.32 ± 0.268	31.7	0.85 ± 0.255	6.3	8.4 ± 0.582	62.0
Female								
January	9	14.39 ± 0.409	4.95 ± 0.151	34.4	1.62 ± 0.159	11.3	7.81 ± 0.192[7]	54.3
February	10	13.95 ± 0.146	4.78 ± 0.987[2]	34.3	1.63 ± 0.082[4]	11.7	7.54 ± 0.124[7,8]	54.0
March	4	13.14 ± 0.041	4.30 ± 0.046[2]	32.7	0.79 ± 0.034[4]	6.0	8.06 ± 0.040[8]	61.3
April	8	13.15 ± 0.313	4.12 ± 0.088	31.3	0.91 ± 0.094	6.9	8.13 ± 0.196	61.8
May	1	13.29	4.19	31.5	0.80	6.0	8.29	62.4

[1-8]Differences significant ($P < 0.05$).

increased significantly to an elevated level maintained until May (Table 3).

Discussion

At Guelph, the plumage produced by the postnuptial (prebasic) molt was heavier than that produced by the prenuptial (prealternate) molt. This finding was contrary to the suggestion of Dawson and Carey (1976). The difference was not due to abrasion of the flight feathers, which were not molted during the prenuptial molt (Middleton 1977b), but was a reflection of real differences between the summer (alternate) and winter (basic) plumages. These findings suggest that either the number of body feathers was greater in the winter than in the summer, an idea supported by Dawson and Carey (1976), or that the actual structure of the winter feathers differed from the equivalent summer feathers, thus rendering them of different weights.

Considerable variation was found in the numbers of contour feathers between four individual American Goldfinches. These limited data hinted at no relationship between numbers of feathers and season, as previously suggested for the goldfinch (Dawson and Carey 1976) and other species (Markus 1963; Lucas and Stettenheim 1972: 195; Dorst 1974: 112). Perhaps the observed variation was consistent with that found in several species (Markus 1965). However, the small sample size must be acknowledged, as must the lack of reliable data on feather numbers for birds in general (Pettingill 1985: 50).

Feathers from winter (basic) and summer

(alternate) plumages of the American Goldfinch differed structurally. Although the number of barbs on each feather was similar, the percentage of plumulaceous barbules was greater in winter, as was the number of barbules. However, the ultrastructure of the barbules and barbicels did not differ. Thus the heavy winter plumage of the American Goldfinch apparently results from gross changes in the structure of the individual feathers that give rise to a more dense, more downy and presumably more effective insulative plumage. Similar changes in plumage structure have been observed for some nonpasserine species (Kuzmina 1961).

At Guelph the monthly levels of carcass fat, water and the lean component were similar to those observed in Michigan (Carey et al. 1978). The importance of these changes in weight and in body composition, as related to overwinter survival, has been adequately discussed elsewhere (Newton 1972; White and West 1977; Carey et al. 1978; King 1980). However, the relationship of molt to these changes has not been thoroughly examined.

At Guelph, the rise in body water levels occurred in March (Table 3), coincident with the start of the prenuptial (prealternate) molt (Middleton 1977b, 1978) and the elevated levels persisted during that molt. Further, in Michigan, body water content also rose during late summer and early autumn (Carey et al. 1978). Thus, at two different locations, elevated water levels coincided with the timing of the prenuptial (prealternate) and postnuptial (prebasic) molts of the American Goldfinch (Dawson and Carey 1976; Middleton 1978), suggesting that elevated water levels are related to the growth of new feathers (Newton 1968; Chilgren 1977). Likewise, the significant decrease in the lean body component occurred during the period of active prenuptial (prealternate) molt, again suggesting a relationship between the two processes, as suggested by King (1980). In addition, comparison of Figures 6 and 7 of Dawson and Carey (1976) showed that the period of inability to cope with extremely cold conditions coincided closely with the appearance and retention of the goldfinch's summer (alternate) plumage. Such relationships suggest that the metabolic processes associated with molt may also influence other physiological changes which become apparent at the same time. This influence would presumably be mediated through the hormonal system (Voitkevitch 1966; Stettenheim 1972).

Thus, although Dawson and Carey (1976) and Carey et al. (1978) assigned secondary importance to molt and the resultant plumages, they may have underestimated their importance to overwinter survival. Despite Dawson and Carey's (1976) observations, it is clear from this study that the goldfinch produces two plumages of different weight and quality. Some internal factor(s) must therefore regulate the differential activity of the feather follicle. That factor could impinge upon other metabolic processes within the body (King 1980).

All organisms are adapted to function within a complex environment. To do so effectively, they must be able to respond to a variety of environmental cues which in turn must be related to their internal physiology. I suggest that the observations reported here, relating to molt and feather structure, and those described by Dawson and Carey (1976) and Carey et al. (1978) relating to metabolic change, are but parts of a complex picture. Thus molt, and subsequently feather structure, may be as important to winter survival by the American Goldfinch as the metabolic changes described by Dawson and Carey (1976) and Carey et al. (1978). Indeed, it could be argued that the latter are a manifestation of internal changes stimulated by the physiology of molt (Middleton 1978).

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Wolf, *Canis lupus*, Numbers and Colour Phases in Jasper National Park, Alberta: 1965-1984

DICK DEKKER

3819 — 112A Street, Edmonton, Alberta T6J 1K4

Dekker, Dick. 1986. Wolf, *Canis lupus*, numbers and colour phases in Jasper National Park, Alberta: 1965-1984. Canadian Field-Naturalist 100(4): 550–553.

In the Snake Indian Valley of Jasper National Park, Alberta, Wolves increased from a minimum of 2 in 1965 to 30 in 1977, and decreased to 4-6 in 1983. These fluctuations parallel Wolf population estimates for the entire park. Of 132 adult Wolves sighted, 53% were black, 45% grey and 2% white.

Key Words: Wolf, *Canis lupus*, abundance, colour phases, Jasper National Park, Alberta.

In the area that is now Jasper National Park, Wolf (*Canis lupus*) populations have fluctuated greatly since the early 1800s when the first white men came to the region. Stelfox (1969) and Carbyn (1974) examined the historical records and traced the cause of the Wolf's decline around the turn of the century to intensive control and scarcity of ungulate populations, which also declined greatly in response to man's activities. After 1907, when Jasper Park was established, indigenous ungulates were protected and reached high densities, causing serious overgrazing of wintering range (Clarke 1942; Flook 1964; Stelfox 1971). Wolves were shot and poisoned in the park until 1959, and poisoning was routine in adjacent provincial forests until 1966 (J. R. Gunson. 1984. Review of management and research of wolf-big game predation in Alberta. Alberta Energy and Natural Resources Report. 24 pp).

Since 1943, two field studies of Wolf-ungulate interactions were carried out in Jasper Park by the Canadian Wildlife Service and Parks Canada. Cowan (1947) used data collected by park personnel; Carbyn (1973) conducted field work in the Snake Indian River region from 1969 to 1972. Both researchers estimated the Jasper Park Wolf population at about 50 animals, or one Wolf per 225 km^2, and both concluded that Wolves were not effective in reducing Elk (*Cervus elaphus*) numbers, which fact Carbyn (1973) attributed to the low Wolf densities.

This study presents data on Wolf numbers on a major Elk range in Jasper National Park, and reports estimates of Wolf populations in the entire park by the Warden Service for the period 1965-1984. It also gives data on the observed colour phases and their proportions in the population.

Study Area and Methods

The study area is the same as used by Carbyn (1973). It measures roughly 500 km^2, and consists of a portion of the valley systems of the Snake Indian and Athabasca rivers in Jasper National Park (Figure 1). Elevations range from 1000 to 2300 m. On the west and east the valley is flanked by the De Smet and Bosche Ranges. Below timberline (± 2100 m) the mountain sides are forested with White Spruce (*Picea glauca*) and Lodgepole Pine (*Pinus contorta*). Trembling Aspen (*Populus tremuloides*) and willow (*Salix* spp.) occur at lower elevations. Valley bottoms are a mosaic of montane meadows, especially in the Willow Creek and Devona districts. The semi-open character of these landscapes allows good opportunities for viewing wildlife.

Wolves occur year-round in the study area, and prey on five to seven species of ungulates. The Willow Creek district in the late 1960s was a major calving ground for Elk (Carbyn 1973). The Devona Flats are a major wintering area for Elk and Bighorn Sheep (*Ovis canadensis*). In both districts Mule Deer (*Odocoileus hemionus*), White-tailed Deer (*Odocoileus virginianus*), and Moose (*Alces alces*) are common. Mountain Goats (*Oreamnos americanus*) and Caribou (*Rangifer tarandus*) are very local or scarce in distribution.

The climate is continental with long cold winters and heavy snowfall, but accumulations on semi-arid slopes at Devona and Willow Creek are usually light, due to the moderating influence of Chinook winds. For a more detailed description of the study area climate, fauna and vegetation, see Carbyn (1973) and Holroyd and Van Tighem (1983).

During the period 1965-1984 I spent a total of 307 days in the Snake Indian Valley. Field trips lasted two to five days. The Willow Creek area was visited two to eight times yearly between 1 June and 31 October, and zero to two times yearly between 1 November and 31 March. The Devona area was visited two to eight times yearly between 1 November and 31 March, and two to three times yearly from 1 April to 31 October. I travelled to the Willow Creek area on foot from Rock

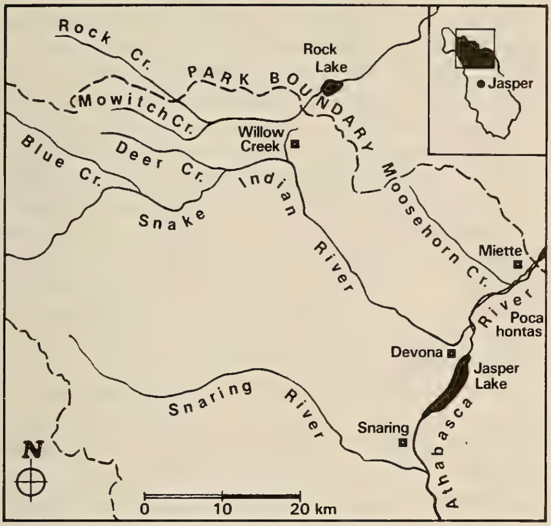

FIGURE 1. Map of the study area in Jasper National Park, Alberta.

Lake at the terminus of the provincial road from Hinton. The Devona area was accessible via the Celestine Lake Road or by crossing Jasper Lake from Highway 16.

During each visit I looked for Wolves and their sign on hiking trails, river banks and meadows. Known Wolf denning and rendezvous areas were checked for evidence of use. At occupied sites I observed adult Wolves and pups through binoculars or a 20x telescope, noting details of their pelage and taking care not to cause undue disturbance. At Devona I used simulated Wolf howls to try to attract Wolves on meadows and riverflats below a lookout hill (Dekker 1985a). I camped on the same sites, using a pup tent during summer, and a larger tent with wood stove during winter. Summer trips were usually made alone, winter trips with a companion.

Information on Wolf sightings in and near the study area was also obtained from district wardens and from trappers on adjacent provincial lands. Estimates of Wolf numbers in the entire park were solicited from Parks Canada and the Warden's Office.

Results

Wolf numbers

During the period 1965-1968 I found Wolf tracks to be common at Willow Creek in all seasons. The District Warden saw a pack of eight Wolves in 1965. One day later, six Wolves were found dead near a poison bait on Rock Lake. Between 1969 and 1972 there was no evidence that more than one pack, 10-12 animals, occurred in the study area. They ranged from Snaring to Moosehorn, and from Devona to Rock Lake and Mowitch Creek (Carbyn 1973). The pack denned at Willow Creek where two dens were used intermittently from 1969 to 1981. In 1977, this pack had grown to 16 animals.

After 1973, a Wolf pack denned at Devona in the lower Snake Indian Valley. The pack contained at least 11 and probably 14 members in the late 1970s, bringing the total Wolf population of the valley to 30 animals. In some years, a pack of four Wolves was reported from Snaring and Moosehorn. In 1981, while I was observing the Willow Creek and Devona packs on their home sites, an adult Wolf with pups was reported at Blue Creek, on the western edge of the study area.

Wolves produced pups at Willow Creek and Devona in 1982, but I found no occupied dens in 1983. In that year only single Wolves or pairs were tracked and seen in the study area. In 1984, Wolf tracks continued to be very scarce at Willow Creek, where I found no evidence of packs or denning activity. However, at Devona Wolf numbers increased again to ten, as evidenced by sightings in the winter of 1984-1985 (Table 1).

Estimates of Wolf numbers in all of Jasper National Park are "only approximate" and show an increase from 48 in 1969 to a maximum of 80-100 in 1974-1976 (The Distribution and Status of Wolves. Background paper no. 6 for Four Mountain Parks Planning Program, p. 10. 1983). However, a Jasper Park Resource Management Memo dated 1981 gives a much higher estimate of 180, reached sometime during the 1970s (Warden John Woodrow, personal communication). A memo dated 1984 puts the number at 75. Wolf sightings reported on Warden Wildlife Cards peaked in 1976, and reached a low in 1984.

TABLE 1. Minimum numbers of Wolves in the Snake Indian Valley of Jasper National Park in years when their population could be estimated with confidence.

Year	Willow Creek	Devona	Totals
1965	2-8	0	2-8
1969	12	2	14
1971	12	2	14
1973	12-14	6-10	18-24
1977	16	8-14	24-30
1980	16	10	26
1982	8-12	10	18-22
1983	2	2-4	4-6
1984	1	10	11

Colour phases

The large subspecies of Wolf found in western North America shows extreme variation in pelage colour from black to white, although pure white is rare. In November 1980, I observed a pure white pup of the year at Devona. An adult seen at Devona in 1982 was white with light grey back. The dominant wolf at Willow Creek in 1981 was white with an oval-shaped grey patch across the rump below the tail. Other unusually coloured Wolves included a silver-grey with black upper rump and tail, and a black one with whitish face, white lower front legs and white rear feet. Few black Wolves were all-black; most showed varying amounts of grey on the head, flanks, legs or neck. In July 1980 and 1981, the Willow Creek pack contained two bronze-coloured Wolves with black heads, legs and tail.

Despite such individual variations in colour pattern, all Wolves seen could be split into three groups: black, grey and white. From 1965 to 1984, I sighted 132 adult wolves, not counting obvious duplications at denning and rendezvous sites; 70 were black, 59 grey, and 3 white (Table 2). Of 14 pups seen in June or July 1978-1981, 9 were black and 5 grey.

Discussion

The percentage of black-phase Wolves sighted in Jasper National Park appears to be the highest reported thus far. It is 65% higher than in sight records from Alaska, and 65% higher than the ratio in kills in northeastern British Columbia and Alberta (Table 2).

The causes of the 1983 decline of the Snake Indian Valley Wolves are not clear, but are possibly tied to food shortages. Sightings of Elk, Moose and Mule Deer in the Willow Creek district dropped by a factor of three to one from 1970 to 1984 (Dekker 1985b). Elk numbers for the whole of Jasper National Park declined from an estimated 2500 in 1971-1973 (Stelfox et al. 1974) to 1000 in 1983-1984 (Parks Canada Resource Management Memo 1984). This reduction in ungulates could have led to a reduction in Wolves. A similar population crash of Wolves in Isle Royale National Park in 1980-1982 was attributed to lowered food supplies, and was probably not precipitated by human interference (R. O. Peterson, R. E. Page, and P. W. Stephens. 1982. Ecological studies of wolves on Isle Royale. Annual Report 1981-1982. [Unpublished] 20 pp.). Wolves in Jasper National Park are not always immune from man-caused mortality. Between 1975 and 1984, two Wolves were killed on the railroad at Devona, and two on the highway at Pocahontas. During the 1970s, trappers and hunters reportedly "shot up" Wolf packs on the north boundary of the park (Al Johnson and Keith Campbell, personal communication). Four wolves were allegedly shot just inside the Park at upper Moosehorn Valley in late summer 1982, a time which coincides with the disappearance of the Willow Creek pack.

Evidently, Jasper National Park is not large enough to contain and protect wide-ranging carnivores such as Wolves. A viable Wolf population is needed in the park if irruptions of Elk numbers, resulting in serious overgrazing of winter range, such as happened in 1940-1970 (Clarke 1942; Flook 1964; Stelfox 1971), are to be avoided in the future.

Acknowledgments

The following persons supplied additional information on Wolf sightings in the study area:

TABLE 2. Colour phases of Wolves in Jasper National Park as a percentage of total sightings, with comparisons to other regions.

Area	% Black	% Grey	% White	Total Sample	Source
Jasper N.P.	53	45	2	132	This study
Jasper N.P.	55	45	0	80	Cowan (1947)
Jasper N.P.	46	54	0	57	Carbyn (1973)
Total for Jasper N.P.	52	47	1	269	
Alaska	32	68	0	254	Peterson et al. (1984)[a]
Alberta	31	68	1	498	Gunson[b]
British Columbia	33	67	0	481	Elliott[c]

[a]Wolves sighted from aircraft in Kenai, Alaska.
[b]Wolves killed in control programs including poisoning. (J. Gunson, Alberta Fish and Wildlife Division. Personal Communication.)
[c]Wolves killed by aerial shooting. (J. P. Elliott. 1984. Unpublished Reports WR-6 and WR-8, Fish and Wildlife Branch, Fort St. John, British Columbia.)

wardens Bob Barker, Doug Eastcott, Keith Foster, Rick Ralph, Norman Woody; trappers Al Johnson and Bert Hansen; and naturalist Keith Campbell. John Woodrow kindly provided access to Jasper Park Warden files. Peter DeMulder greatly assisted with fieldwork during winter trips. In 1982-1984 the study was financially supported by the Canadian Wolf Defenders, the Alberta Parks, Recreation and Wildlife Foundation and the World Wildlife Fund, Canada. L. Carbyn, J. Gunson, J. Stelfox and W. Wishart read an earlier version of the manuscript.

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Notes

Rodent Fleas (Siphonaptera) in Tree Cavities of Woodpeckers in Alaska

Glenn E. Haas[1] and Nixon Wilson[2]

[1]557 California Street, No. 7, Boulder City, Nevada 89005
[2]Department of Biology, University of Northern Iowa, Cedar Falls, Iowa 50614

Haas, Glenn E., and Nixon Wilson. 1986. Rodent fleas (Siphonaptera) in tree cavities of woodpeckers in Alaska. Canadian Field-Naturalist 100(4): 554–556.

Eighteen specimens of rodent fleas were collected from nine nests (40 searched) of woodpeckers in tree cavities in dead stubs. Tree squirrel fleas predominated with 1/2 of the specimens being *Ceratophyllus vison* and 1/3 *Orchopeas caedens durus*. The tree squirrel flea *Tarsopsylla octodecimdentata coloradensis* and vole fleas *Catallagia charlottensis* and *Megabothris abantis* were represented by one specimen each. Studies of total populations of tree squirrel fleas should include tree cavities, even those not containing squirrel nests. Most of the rodent fleas collected from the cavities probably were lost there by visiting Red Squirrels, *Tamiasciurus hudsonicus*, and Martens, *Martes americana*.

Key Words: Fleas (Siphonaptera), ecology, Red Squirrel, *Tamiasciurus hudsonicus*, tree cavities, woodpecker nests, Marten, *Martes americana*, Alaska.

In a detailed ecological study of tree cavities in the Midwest, Park et al. (1950) indicated that the rich variety of arthropod inhabitants depended on many factors. Successive nesting by such cavity residents as woodpeckers, mice, and squirrels together with subsequent occurrence of bird and mammal ectoparasites, such as fleas and mites were noted, but the emphasis of their study was on certain beetles. In Alaska, we studied woodpecker nest cavities as a habitat for bird fleas (Haas et al. 1981; Haas and Wilson 1984) and found that multi-use of the cavity involving nesting Red Squirrels (*Tamiasciurus hudsonicus*) and Northern Red-backed Voles (*Clethrionomys rutilus*) resulted in the occurrence of fleas of these rodents (Haas and Wilson 1982; Haas 1982). We also found that cavities not containing rodent nests were occasionally infested with rodent fleas; the present report concerns records of 18 specimens of these fleas: *Ceratophyllus vison, Orchopeas caedens durus, Tarsopsylla octodecimdentata coloradensis, Catallagia charlottensis*, and *Megabothris abantis*.

Materials and Methods

The rodent fleas were collected incidentally to our survey of bird fleas in unoccupied nests of woodpeckers (Haas and Wilson 1984). Inspection of approximately 60 woodpecker tree cavities yielded 40 nests that were in satisfactory condition for flea studies.

Results

Eighteen specimens of five species of rodent fleas, represented by one to nine specimens each, were collected from nine nests of woodpeckers (Table 1). Bird fleas occurred in eight of these nests and in 31 others (Haas and Wilson 1984). The nine cavities (Table 1) averaged 3.4 m above ground level in dead stubs of trees located in four relatively dry districts, i.e. the Copper Basin, the Interior, Matanuska Valley, and West Kenai Peninsula.

Localities and sites of nest cavities by nest number (Table 1):

1. Palmer, 18.2 km SE [Knik River Road near Fox Lake] (61°27′N, 148°52′W), nest of *Picoides* sp. (woodpecker) in cavity 1.7 m up dead White Spruce (*Picea glauca*) stub.

2. Palmer, 1.6 km N (61°38′N, 149°06′W), nest of *Picoides* sp. in cavity 3 m up dead cottonwood (*Populus* sp.) stub.

3. Nabesna Road, mile 24.5 [39.2 km] (62°33′N, 143°29′W), nest of *Colaptes auratus* (Northern Flicker) in cavity 4 m up dead spruce stub.

4. Chistochina, 22.5 km SW [mile 222.5 Glenn Highway] (62°25′N, 145° W), nest of *Picoides villosus* (Hairy Woodpecker) or *Picoides pubescens* (Downy

Woodpecker) in cavity 3 m up dead White Birch (*Betula papyrifera*) stub.

5. Kenai [city] (60°34′N, 151°17′W), old nest of *Picoides* sp. in cavity 2 m up rotten birch stub, with some evidence of nesting by *Parus* sp. (chickadee).

6. Glennallen, 51 km W [mile 3 (4.8 km) Lake Louise Road] (62°09′N, 146°17′W), nest of *Colaptes auratus* in cavity 4 m up dead White Spruce stub.

7. Glennallen, 53 km W [mile 4.5 (7.2 km) Lake Louise Road] (62°11′N, 146°18′W), nest of *Picoides* sp. in cavity probably of *Colaptes auratus* 2.5 m up dead White Spruce stub.

8. Fairbanks, 35 km WSW [mile 336 Parks Highway] (64°44′N, 148°22′W), nest of *Colaptes auratus* in cavity 5 m up dead birch stub.

9. Same locality as number 6, nest of *Colaptes auratus* in cavity 5 m up dead White Spruce stub.

Discussion

The collection of rodent fleas was small (Table 1), but it illustrated certain aspects of flea ecology. Undoubtedly other specimens escaped detection. The quality of a woodpecker nest cavity as a habitat for fleas changed over time so that the contents of very old cavities had become so compacted, especially when remains of ants were present, that a search for dead fleas was futile. As indicated in the introduction, our data from the newer cavities provided valuable insight into the multi-use of cavities by birds and mammals and the consequent occurrence of their fleas in the same habitat. Jurik's (1974, 1976) thorough studies of fleas in birds' nests in Czechoslovakia according to "Zones of Aphaniptera" (= Siphonaptera) showed that the zone of the fleas of birds that build nests in tree crowns, hollowed trees (boxes), and shrubs has the strongest linkage with the zone of the fleas of the arboreal-nesting squirrel, *Sciurus vulgaris*. Our short series of collecting records from Alaska showed a strong parallel involving the woodpecker nest cavities in tree stubs and the arboreal habits of the Red Squirrel.

The three taxa and 16 specimens of tree squirrel fleas (Table 1) ranked in the same order of abundance as in the collection of 867 specimens from arboreal nests of the Red Squirrel mostly in the same regions of Alaska (Haas and Wilson 1982). Ten of the 39 infested squirrel nests were built inside old woodpecker nest cavities. The multi-use of woodpecker cavities suggests that any total population study of Red Squirrel fleas in forests with woodpecker nest cavities in the trees should include sampling of the tree cavities for squirrel fleas.

The rodent fleas collected (Table 1) are not known to have well-developed, arboreal perambulatory habits, so they were most likely lost in the woodpecker cavities by tree-climbing rodents, especially Red Squirrels. Some of the fleas were probably left behind in the cavities by visiting predators such as Martens, *Martes americana*. These mammals are known to enter tree cavities in California (Spencer and Zielinski 1983), and in Alaska there is a record of *Monopsyllus* (= *Ceratophyllus*) *vison* and several of *O. caedens durus* from Martens (Hopla 1965). The relative scarcity of *T. octodecimdentata* in the cavities (Table 1) is attributable to general uncommonness of the flea and to its being a nest-flea, thus reducing the

TABLE 1. Rodent fleas in nests of woodpeckers in tree cavities in Alaska, 1974-1976.*

Nest number	Date	*Ceratophyllus vison*	*Orchopeas caedens durus*	*Tarsopsylla octodecimentata coloradensis*
1	28 July 74	♂(dead)		
2**	3 Aug. 74	♀(gravid)		
3	2 Sept. 75		4♀♀	
4	9 Apr. 76	♂ 2♀♀(all dead)		
5	23 Apr. 76	♀(dead)		
6	8 June 76		♂	
7	14 June 76	♀(dead)	♀(dead)	
8	29 June 76	♀(dead)		
9	27 Sept. 76	♂		♀

*Locality and site data listed under Results.

**Also *Catallagia charlottensis* ♂ (engorged) and *Megabothris abantis* ♂; bird fleas absent, but five species represented in collections from the other nests.

likelihood of its riding about in fur of Martens and Red Squirrels.

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Where do Juvenile Atlantic Wolffish, *Anarhichas lupus*, live?[1]

D. W. KEATS,[2] G. R. SOUTH,[2,3,4] and D. H. STEELE[2]

[1]Newfoundland Institute for Cold Ocean Science Contribution No. 94
[2]Department of Biology, Memorial University of Newfoundland, St. John's, Newfoundland A1B 3X9
[3]Newfoundland Institute for Cold Ocean Science, Memorial University of Newfoundland, St. John's, Newfoundland A1B 3X9
[4]Present address: Huntsman Marine Laboratory, Brandy Cove, St. Andrews, New Brunswick E0G 2X0

Keats, D. W., G. R. South, and D. H. Steele. 1986. Where do juvenile Atlantic Wolffish, *Anarhichas lupus*, live? Canadian Field-Naturalist 100(4): 556–558.

A size frequency histogram for Atlantic Wolffish collected on the Avalon Peninsula, Newfoundland is presented. No individuals smaller than 50 cm total length were collected or observed. It is concluded that the juveniles do not inhabit shallow water where adults migrate in spring to spawn. The most likely habitat for juvenile Atlantic Wolffish is offshore in deeper water. It is probable that Atlantic Wolffish only appear in shallow water when they have reached sexual maturity and are ready to spawn.

Key Words: Atlantic Wolffish, *Anarhichas lupus*, Newfoundland.

During the period 1982-1985 we have studied the feeding and behavior of the Atlantic Wolffish (*Anarhichas lupus*) in Newfoundland. All individuals seen while on collecting dives on the Avalon Peninsula were taken using spear guns. In addition to collections, observations were made on dives conducted for other purposes. Although diving was concentrated around the spring-autumn period, at least three dives were made per month during the winter. As part of the study we measured the lengths of all specimens collected (Figure 1). No specimens smaller than 50 cm were collected or observed. Most specimens were in the range 70 to 90 cm, indicating ages from 9 to 18+ years (Beese and Kandler 1969).

Adult Wolffish are common in inshore waters from the spring until late autumn, and egg masses are deposited during September–October (Keats et al. 1985). We have observed larval wolffish in the water column during the hatching period (October–November), but newly settled juveniles

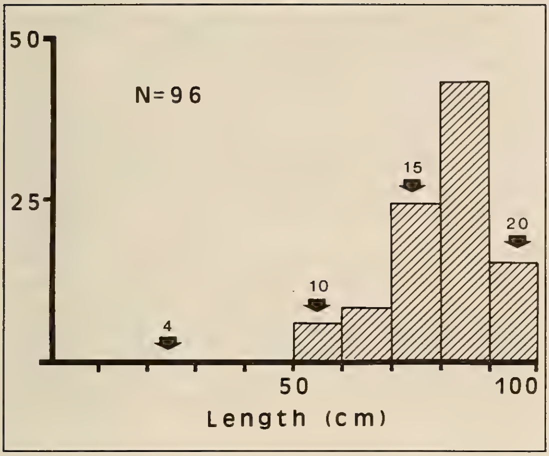

FIGURE 1. Length frequency distribution for the 96 Atlantic Wolffish collected during the present study. Numbers above the histograms are the ages for the particular size class [from Beese and Kandler (1969)].

have never been recorded. Considerable searching under rocks, under scallop shells, and among algae has been conducted on bottom ranging from mud to mainly bedrock, but no small wolffish were observed. It is therefore evident that juvenile wolffish do not occur inshore in shallow water (< 30 m) around Newfoundland.

There are two possible explanations for the observed absence of juvenile fish in shallow water. First, little or no recruitment may have occurred during the last ten years. Second, juveniles may occupy habitats offshore or in deeper water until they attain sexual maturity. The smallest size class collected during the present study was 50 cm. Beese and Kandler (1969) reported that female *A. lupus* mature at 31–46 cm, and males at 42–69 cm. This is close to the size range at which they begin to appear inshore (Figure 1).

Based on dentition, Barsukov (1959) concluded that yearlings (7 cm) feed on molluscs and other hard organisms. We can therefore rule out the possibility of an extended pelagic period for juveniles, such as occurs for*Anarhichas denticulatus* (Grigor'ev 1983) and the Pacific species *Anarrhichthys ocellatus* (Miller 1982; Wakefield 1980). The latter species does not develop adult dentition until 50–60 cm in length (Kanazawa 1952).

Juvenile wolffish have been reported at other locations, but in many cases the habitat or depth range sampled was not given. Barsukov (1959) stated that young wolffish are particularly confined to stony bottom, but gave no localities, depths or specific data. Beese and Kandler (1969) reported that 24 of 124 specimens taken off Greenland were less than 30 cm in length. Smidt (1981) reported a length frequency distribution for *A. lupus* from trawl and longline catches off Greenland (ICNAF Div 1D). Peak abundance was within the 55–65 cm size range, with no individuals below 35 cm or larger than 80 cm. The lack of small individuals in this case may be a result of sampling gear selectivity. A small percentage of specimens less than 30 cm (7%) were taken in the North Sea using close-mesh herring trawl nets (Beese and Kandler 1969). Depth ranges for sampling were not provided, but were certainly much deeper than the depth range over which the present samples were gathered. Jonsson (1982) reported that wolffish between 15–35 cm (3–6 years) are caught "in considerable numbers" off Iceland in winter, but gave no details of depth or habitat. There is one report of juvenile Atlantic Wolffish in shallow water: Fabricius (1790) observed that juveniles occur in seaweed beds off Greenland.

There is some indication that juvenile Atlantic Wolffish occur in deeper, offshore water. They were present in samples from 65–430 m between Greenland and Iceland (Kotthaus and Krefft 1957). Baranenkova et al. (1960) reported that in the Barents Sea young Atlantic Wolffish (7–19 cm) were found at 100–200 m, where they fed mainly on echinoderms and molluscs. Nizovtsev (1963) reported that when a trawl with a 10 mm cod end was used, juvenile Atlantic Wolffish were common in samples from 95–540 m off Spitsbergen. There are five specimens of *A. lupus*, ranging from 29.5 to 47 cm, in the Ichthyology Collection (Cat. No. 64 760), National Museum of Natural Sciences, National Museums of Canada, Ottawa. They were collected by otter trawl from ca. 200 m depth at 51°23′30″N, 51°00′00″W off Newfoundland.

A number of studies of feeding and morphometrics of *A. lupus* have been conducted in the Newfoundland region (Albikovskaya 1981, 1982, 1983; Templeman 1983, 1984), but they have either not reported length frequency distributions, or have employed highly size-selective sampling gear. We must conclude that the location and habitat of young *A. lupus* in the northwest Atlantic is unknown. To understand the life cycle, ecology, and fishery biology of the species it is necessary to acquire this knowledge. We hypothesize that young Atlantic Wolffish occupy deeper, offshore water, and only migrate inshore to spawn when they attain sexual maturity.

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Observation of Feeding Interactions Between Coyotes, *Canis latrans*, in Fundy National Park, New Brunswick

DONALD G. KIMBALL[1] and L. DALE MORTON[2]

Canadian Wildlife Service, P.O. Box 1590, Sackville, New Brunswick E0A 3C0
[1]Present address: 150 Bliss St., Fredericton, New Brunswick E3B 5T1
[2]Present address: MFRC, Canadian Forestry Service, P.O. Box 4000, Fredericton, New Brunswick E3B 5P7

Kimball, Donald G., and L. Dale Morton. 1986. Observation of feeding interactions between Coyotes, *Canis latrans*, in Fundy National Park, New Brunswick. Canadian Field-Naturalist 100(4): 559–560.

A unique opportunity to observe eastern Coyotes (*Canis latrans*) at close range feeding under natural conditions is recorded. An exchange of threat displays was exhibited between the known mated pair and a third individual; within the pair dominance was expressed by the male. Aggressive displays by eastern and western Coyotes at feeding sites appear similar.

Key Words: Eastern Coyote, *Canis latrans*, feeding interactions, New Brunswick.

Although there is considerable behavioral information available about the western Coyote (Bekoff 1978; Fox 1975; Ryden 1975), little has been published on its eastern counterpart. The following is an account of a 2 hour observation by Kimball documenting threat displays of eastern Coyotes that are typical of western Coyote behavior.

At approximately 1300 h, 9 February 1985 while snowtracking Coyotes in mixedwood habitat in Fundy National Park, Kimball observed a small reddish-blonde Coyote feeding approximately 30–40 m away on a partially exposed moose (*Alces alces*) carcass. The temperature was approximately −5°C and heavy, wet snow was falling. Winds were light from the feeding site toward the observer.

Two other Coyotes then approached the carcass from their beds approximately 15 m directly behind the carcass. One was a large male with a grizzled grey upper body and buff-coloured underparts and legs. The other was a smaller uniformly grey female wearing a radio collar identifying her as a study animal captured and marked 1 June 1984. This observation occurred during the pre-breeding season (as evidenced by vulval blood in the bed of the radio collared female) when pair bonds are very strong. While the red Coyote fed, the other two returned to the bedding site where, without visible signs of provocation, the more dominant male attacked the female. After 5 to 10 seconds of snapping, snarling and yelping, the confrontation abruptly ended. The female then approached the carcass, where the red Coyote was still feeding. Met with yawning-like gestures, low head position, tail tucked tightly between the legs, and the stiff-legged approach of the red Coyote, the female returned to the bedding site, approaching the large grey male with tail-wagging, playful gestures. Receiving no response she then curled up beside him. Periodically both male and female raised their heads to glance at the red Coyote still feeding. They remained in their resting positions for the following 11 minutes.

The male then approached the carcass followed closely by the female, both animals with hunched backs and heads moving from side to side with the exaggerated gaping-jaw display described by Lehner (1978). No audible sounds accompanied the motions, and after a half-hearted counter display by the red Coyote, the mated pair began to feed. The pair remained at the feeding site for 6 minutes before the red Coyote displayed again. The grey male directed another attack at his mate which retreated yelping to the bedding site. Three minutes later a stiff-legged rush from the red animal caused the grey male to move in an unhurried manner to the bedding site where he lay down beside the resting female. There the pair remained for the following 20 minutes, motionless except for occasionally sniffing the air. At 1454 h, after rising, stretching and pausing to shake the wet snow from his coat, the grey male again approached the carcass, only to be met once more by displays from the red Coyote. Two minutes later the wind appeared to have changed direction. Catching the observer's scent, the red Coyote bolted from the carcass while the mated pair fled in the opposite direction. No audible warnings were heard as they left the site.

Like its western counterpart, the eastern Coyote will tolerate conspecifics at a feeding site, at least within certain ill-defined limits. Ryden (1975) observed western Coyotes tolerating certain other Coyotes at their feeding sites. Her conclusion that those accepted individuals were genetically related from an earlier dispersal suggests that the small red Coyote was related to one of the mated pair.

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Documented Range Extension of the Mountain Goat, *Oreamnos americanus*, in Alaska

LARRY AUMILLER and WARREN B. BALLARD

Alaska Department of Fish and Game, P.O. Box 1148, Nome, Alaska 99762

Aumiller, Larry, and Warren B. Ballard. 1986. Documented range extension of the Mountain Goat, *Oreamnos americanus*, in Alaska. Canadian Field-Naturalist 100(4): 560.

The presence of Mountain Goats along a drainage of Portage Creek in the northern Talkeetna Mountains (62°59′N, 149°08′W) was confirmed in 1982 and 1983.

Key Words: Mountain Goat, *Oreanmos americanus*, range extension, Alaska.

Mountain goats (*Oreamnos americanus*) are distributed in Alaska along the coastal mountains from extreme southeastern Alaska to Cook Inlet (Klein 1953; Johnson 1977; Ballard 1977). Klein (1953) reported the sighting of goats in the northern Talkeetna Mountains and McKinley National Park in the early 1950s. If sightings were correct, they were the farthest northern observations of goats in Alaska. In 1971, L. Nichols recorded one goat observation in the southern Talkeetna Mountains at Iron Creek. The occurrence of goats in the northern Talkeetna Mountains, however, was never verified by staff of the Alaska Department of Fish Game from 1951 through mid-1982 during 18 aerial Dall Sheep (*Ovis dalli*) surveys.

On 3 December 1982, H. McMahan and L. Aumiller observed eight adult goats at 1067 m elevation along a drainage of Portage Creek in the northern Talkeetna Mountains (62°59′N, 149°08′W). The location was verified on 19 March 1983 by W. Taylor and H. Griese who identified four adult goats.

Both observations were of adult goats, suggesting that either kid survival was poor or that adult goats were attempting to colonize vacant habitat. Within the past several years, Sitka Black-tailed Deer (*Odocoileus hemionus sitkensis*) have extended their range into interior southcentral Alaska, apparently in response to mild winter conditions (Roberson 1986). Perhaps mild winter conditions have also allowed Mountain Goats to temporarily extend their range into the northern Talkeetna Mountains. Another contributing factor could be that the area has been closed to goat hunting since 1977. In any case, these observations represent the northernmost verified sightings of the Mountain Goat in Alaska.

Acknowledgments

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Double-crested Cormorant, *Phalacrocorax auritus*, Egg Ejection

WILLIAM J. VAN SCHEIK and VICTOR LEWIN

Department of Zoology, The University of Alberta, Edmonton, Alberta T6G 2E9

Van Scheik, William J., and Victor Lewin. 1986. Double-crested Cormorant, *Phalacrocorax auritus*, egg ejection. Canadian Field-Naturalist 100(4): 561–562.

Egg-ejection by a Double-crested Cormorant (*Phalacrocorax auritus*) was observed and recorded on videotape in a southern Alberta colony. An adult cormorant, believed to be an intruder, succeeded in ejecting an egg from the nest after three attempts. No effort was made by the nest owner to retrieve the egg even though it was plainly visible and near the nest.

Key Words: Double-crested Cormorant, *Phalacrocorax auritus*, egg-ejection, Alberta.

Eggs are commonly found outside nests in Double-crested Cormorant (*Phalacrocorax auritus*) colonies. How the eggs get out of the nest is a matter of speculation. Brechtel (1983) considered eggs outside nests to have been "kicked out" of the nest. Since cormorants incubate their eggs by rolling them on top of their totipalmate feet (Van Scheik 1985), an abrupt disturbance causing startled flushing could result in eggs being kicked out of the nest. This may account for most of the eggs found outside nests in cormorant colonies. Here we report an instance of deliberate ejection of an undamaged egg.

Egg ejection, the removal of an egg from an active nest, is practised by most birds if the egg is dented or cracked. Communal nesting species such as Groove-billed Anis, *Crotophaga sulcirostris* (Vehrencamp 1977), Rheas, *Rhea americana*, (Bruning 1974), Ostrich, *Struthio camelus*, (Bertram 1979), and Acorn Woodpeckers, *Metanerpes formicivorus*, (Stacey and Koenig 1984) are reported to eject undamaged eggs from active nests. In these cases, egg ejection was done by conspecific, often related birds. Explanations for this behavior have varied and include poor breeding synchrony (Bruning 1973), inadequate nest (Lancaster 1964), and female competition (Vehrencamp 1977; Stacey and Koenig 1984).

The documentation of egg ejection by conspecifics in noncommunal nesting species is uncommon. While videotaping nesting behavior of Double-crested Cormorants on 15 May 1984 at Scope Reservoir near Vauxhall, Alberta, 50°3′N, 112°8′W, an egg-ejection incident occurred. The return of the cormorants to the colony 3 minutes following our departure was recorded on videotape. A returning bird landed on a nest at the edge of the colony, and without behavior typical of nest ownership (bowing over the eggs, settling on eggs, and arranging nest material) it grasped one of the two eggs in its bill and attempted twice to eject it from the nest before succeeding on the third attempt. It departed 18 seconds after ejecting the egg. A further two minutes and 37 seconds elapsed before another bird exhibiting typical ownership behavior arrived at the nest and settled over the remaining egg. The second bird made no effort to recover the egg, which was plainly visible and within reach of the nest.

Individual cormorants are difficult to tell apart unless marked; however, on the basis of the failure of the first bird to perform usual arrival behavior, we are confident the egg ejection was done by an intruder. Lewis (1929) described a similar episode among the Double-crested Cormorants he studied in Quebec. The significance of this type of behavior is unclear, but it may account for some of the eggs commonly found outside the nests in cormorant colonies. While it is not uncommon to find eggs outside nests in undisturbed colonies, this observation may account for how some got there.

Acknowledgments

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Encounters Between Arctic Foxes, *Alopex lagopus*, and Red Foxes, *Vulpes vulpes*

DOUGLAS SCHAMEL and DIANE M. TRACY

Institute of Arctic Biology, University of Alaska, Fairbanks, Alaska 99775-0280

Schamel, Douglas, and Diane M. Tracy. 1986. Encounters between Arctic Foxes, *Alopex lagopus*, and Red Foxes, *Vulpes vulpes*. Canadian Field-Naturalist 100(4): 562–563.

Arctic Foxes avoided close encounters with Red Foxes, even when such avoidance interfered with food caching.

Key Words: *Alopex lagopus*, Arctic Fox, *Vulpes vulpes*, Red Fox, animal behavior, Alaska.

Reports of interactions between Arctic Foxes (*Alopex lagopus*) and Red Foxes (*Vulpes vulpes*) in the wild are rare. In a fox-farming venture in southern Alaska, a single male Red Fox reportedly killed the numerous Arctic Foxes on one island (Ashbrook and Walker 1925). Chirkova (1967) reviewed the Soviet literature on this topic and found few references to Red Foxes attacking Arctic Foxes or vice-versa. In this paper, we report three observations of encounters between these two species of foxes in the wild.

We made our observations at Cape Espenberg (66°35′N, 163°45′W), the northernmost cape of the Seward Peninsula in western Alaska. The treeless cape consists of a series of ancient dune ridges, interspersed with ponds and marsh. The 20 km² of marshes on the cape are nesting habitat for thousands of waterbirds in summer; Arctic Ground Squirrels, *Spermophilus parryii*, live in the dunes. We recorded all sightings of foxes during the summers of 1976, 1977, and 1978 incidental to our study of waterbird productivity. Both species were observed frequently only in 1977. Two pairs of Red Foxes produced pups on the cape in 1976; no Arctic Foxes were seen that year. No Arctic Fox pups were observed in any year. We observed two interactions between fox species from an observation blind at the edge of a 25 ha nesting density study plot. We used the blind to observe predator activity within the study plot.

During the evening of 7 July 1977 an Arctic Fox was caching eggs from an Oldsquaw, *Clangula hyemalis*, nest. It took five eggs (one at a time) from the nest, burying each at different distances from the nest. After burying the fifth egg, the fox looked to the west, then began running toward the east. A few seconds later, a Red Fox was seen within 100 m of the area just vacated by the Arctic Fox. The Red Fox located the Oldsquaw nest and removed the remaining two eggs. In the late evening of 10 July 1977 an Arctic Fox was hunting in the same vicinity. It stopped, looked to the southwest, then began running northeast. Four minutes later a Red Fox was sighted on the spot vacated by the Arctic Fox. In both instances, the Arctic Foxes continued running on their initial courses until they were lost from view (about 800–1000 m between the Red and Arctic foxes). In both instances, the Red Fox approached from the direction of the apparent disturbance to the Arctic Fox. When initially sighted, the Red Foxes were moving across the tundra at their normal hunting lope. There was no evidence that they were responding to either the Arctic Fox or to some other disturbance.

At 2115 h of 11 July 1977, loud screaming vocalizations drew our attention to an Arctic Fox and a Red Fox on a beach about 200 m distant. The foxes were about 2 m apart. The Arctic Fox was waving its tail over its back, the front part of its body (including the head) was low, nearly touching the sand, and its haunches were held high. After a few seconds, the Arctic Fox trotted away. When the distance between

foxes was about 50 m, the Red Fox trotted after it. Then the Arctic Fox began to run, followed by the Red Fox. The Red Fox chased to within 5 m, then the Arctic Fox put on a burst of speed and quickly outdistanced it. The Red Fox stopped to check a bird that had flushed. The Arctic Fox then stopped, turned to face the Red Fox (at a distance of 15–20 m), waved its tail and vocalized. The Arctic Fox then ran, followed by the Red Fox (at a distance of 15–20 m) and both disappeared from view behind a dune ridge.

The initial posturing of the Arctic Fox in the third incident was similar to the "invitation to play" posture of most canids. The Arctic Fox may have reacted with a form of submissive behavior, play, after encountering the Red Fox on the beach. In the other two incidents, Arctic Foxes clearly avoided close encounters with Red Foxes, even when such avoidance behavior interfered with food caching.

Our field observations correspond with the results of a study by Rudzinski et al. (1982) of Arctic and Red foxes in a 4 ha enclosure. Red Foxes dominated Arctic Foxes in behavioral interactions, and Arctic Foxes tended to restrict their movements, apparently to avoid contact with Red Foxes (Rudzinski et al. 1982).

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Range Extension of the Sitka Black-tailed Deer, *Odocoileus hemionus sitkensis*, in Alaska

KENNETH ROBERSON

Alaska Department of Fish and Game, Box 47, Glennallen, Alaska 99588

Roberson, Kenneth. 1986. Range extension of the Sitka Black-tailed Deer, *Odocoileus hemionus sitkensis*, in Alaska. Canadian Field-Naturalist 100(4): 563–565.

A range extension of at least 175 km for Sitka Black-tailed Deer (*Odocoileus hemionus sitkensis*) in southcentral Alaska is described.

Key Words: Sitka Black-tailed Deer, *Odocoileus hemionus sitkensis*, distribution, Alaska.

Sitka Black-tailed Deer (*Odocoileus hemionus sitkensis*) were successfully introduced to Prince William Sound in southcentral Alaska in 1916 (Burris and McKnight 1973). Prince William Sound is a fjord-like estuarine system containing numerous islands surrounded by glacial ice fields at the northern edge of the Gulf of Alaska. Islands and non-glaciated shoreline of the sound are suitable deer habitat up to elevations of 450 to 750 meters, typically vegetated with dense stands of Sitka Spruce (*Picea sitchensis*) (Klein 1979). Since their introduction in 1916 deer populations have fluctuated in response to thick snow cover (Reynolds 1979). Both climate and topographic barriers were thought to preclude further northern expansion (Wallmo 1981). This report documents a northern range extension of at least 175 km into the Copper River Basin.

Initial sightings of deer in the Copper River Basin were reported in 1972. Between 1980 and 1984 the frequency of such sightings increased and total 19 to date (Figure 1). Early sightings were initially questioned; however, in 1981 a sighting was made by

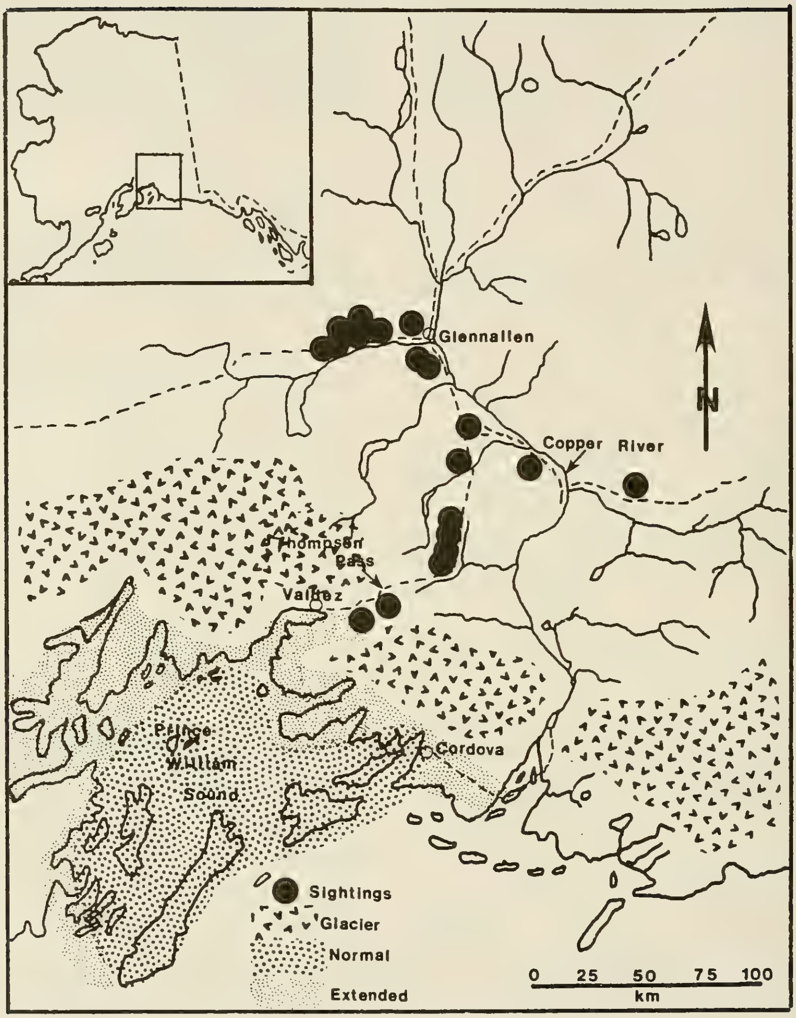

FIGURE 1. Locations of Sitka Black-tailed Deer normal range (large speckles), mild winter extended range (small speckles) and new range sightings (solid circles) in southcentral Alaska.

the author and two other biologists. Also, a later sighting was verified by the author from a photograph. The sightings range over 150 km of highway and the most northern location is 175 km north of the known distribution (Julius Reynolds, personal communication). Deer may have travelled to the Basin either over Thompson Pass or through the Copper River canyon, both of which lack icefields. The Thompson Pass hypothesis is supported by 17 of the 19 observation records. Two records tend to support use of the Copper River route. Concurrent use of both routes is possible.

During the 1979-84 period the Copper River Basin experienced mild winters in terms of snow cover thickness and temperature. Mild winter conditions also occurred in Prince William Sound and deer populations subsequently increased (Julius Reynolds, personal communication). Thus deer density may have been a factor in this range extension. The long-term survival of deer in the Basin is doubtful, mainly because of potential extreme winter temperatures of −21°C (Bishop and Rausch 1974) and snow cover

thickness of 173 cm (Skoog 1968), which will make browse (*Vaccinium* sp. and *Ribes* sp.) unavailable because they occur mainly in open areas. Lastly, predation, even though opportunistic, could account for some mortality, along with poaching and highway losses.

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A Coyote, *Canis latrans*, on Prince Edward Island

HOWARD H. THOMAS[1] and RANDALL L. DIBBLEE[2]

[1]Department of Biology, Fitchburg State College, Fitchburg, Massachusetts 01420
[2]Fish and Wildlife Division, Community and Cultural Affairs, Charlottetown, Prince Edward Island C1A 7N8

Thomas, Howard H., and Randall L. Dibblee. 1986. A Coyote, *Canis latrans*, on Prince Edward Island. Canadian Field-Naturalist 100(4): 565–567.

This is the first record of the Coyote, *Canis latrans*, from Prince Edward Island. Weight and twenty cranial measurements are listed. The cranial measurements are compared with those of other studies to determine taxonomic status. The single island specimen was determined to be a *C. latrans* whose cranial morphology was within the size range for New Brunswick *Canis latrans*.

Key Words: Coyote, *Canis latrans*, Prince Edward Island, new record.

The Coyote (*Canis latrans* Say) was first reported from the Maritime Provinces of Canada in 1966 as a result of a road-killed specimen near Debec, Carleton County, New Brunswick (Cartwright 1975). This animal was believed to have originated from a nearby Maine population (Cartwright 1975). Since then *C. latrans* has expanded its range eastward into the remainder of New Brunswick and Nova Scotia (Cartwright 1975; O'Brien 1983). O'Brien (1983) reported that the first Nova Scotia record was from Guysborough County in 1977. Additional Nova Scotia records have occurred since then (O'Brien 1983). However, there have been no records of *C. latrans* from the province of Prince Edward Island.

On 29 November 1983, a male wild *Canis* was trapped north of Souris Township, Kings County, Prince Edward Island. Based on external markings, field identification classified the specimen as *Canis latrans*. Only the skull, which is deposited at the University of Prince Edward Island, was saved. Skinned weight and twenty cranial measurements were recorded from the specimen (Table 1).

The taxonomic status of the Prince Edward Island canid specimen was determined by comparing cranial measurements with previous studies (Howard 1949; Lawrence and Bossert 1967, 1969; Nowak 1979). Muzzle sizes were compared utilizing the ratio of palatal width at P1 to alveolar length of maxillary tooth row (Howard 1949). The ratio obtained for the island specimen (35%) fell within the range of values

TABLE 1. Measurements and discriminant scores of the adult *Canis latrans* from Prince Edward Island; mean measurements, (n), and range of *Canis latrans* from New Brunswick and *Canis familiaris*.

Measurement	Prince Edward Island *Canis latrans*	New Brunswick *Canis latrans*	*Canis familiaris*[4]	Discriminant function values[5] *latrans–familiaris*	*latrans–lupus*
Weight (g)	13343.4(1)	—	—	—	—
Maximum length[1]	199.6(1)	198.7(21) 184.6-216.0	217.2(50) 151.0-285.0	— —	— —
Zygomatic width[2]	109.6(1)	102.5(17) 92.3-113.6	112.4(50) 84.0-154.0	8.06	-3.90
Braincase width[2]	59.9(1)	59.3(17), 56.1-61.9	59.0(50), 50.5-65.0	-3.36	4.49
Alveolar length of maxillary toothrow[1]	67.5(1)	69.7(20), 61.9-80.2	70.2(50), 52.5-88.0	— —	— —
Maximum crown width across upper cheek teeth[2]	56.9(1)	59.4(24), 54.6-66.1	68.1(50), 51.5-85.5	-3.21	-0.14
Palatal width at P1[1]	23.8(1)	21.8(14), 19.9-25.7	29.8(50), 21.5-42.3	-1.84	0.15
Rostral width at C1[1]	33.1(1)	32.5(9), 29.6-35.1	41.6(50), 30.9-59.0	—	—
Width of frontal shield[1]	53.8(1)	48.7(23), 44.3-59.9	60.9(50), 40.5-87.4	—	—
Postorbital constriction[1]	38.9(1)	36.0(22), 28.6-39.9	39.2(50), 32.2-44.8	—	—
Length from toothrow to bulla[2]	52.7(1)	48.6(18), 42.5-54.6	60.2(50), 33.6-88.0	-4.46	3.39
Height from maxillary toothrow to orbit[2]	26.9(1)	28.7(24), 25.3-32.8	33.6(5), 20.5-53.5	-4.54	-0.99
Depth of jugal[2]	14.0(1)	13.3(23), 11.5-15.7	15.3(50) 10.1-23.6	2.21	0.23
C1 diameter[2]	9.7(1)	9.7(23), 7.8-11.1	11.2(50), 8.4-14.0	-3.77	-1.21
P4 crown length[2]	19.3(1)	20.4(25), 17.5-22.6	19.3(50), 14.4-22.7	6.45	1.45
M2 crown width[2]	12.3(1)	11.0(24), 8.9-12.9	10.9(50) 7.7-13.0	3.93	0.23
Maxillary toothrow crown length[3]	83.4(1)	-	-	-10.44	4.13
Upper incisor crown width[3]	25.6(1)	-	-	-3.68	-1.15
P4 crown width[3]	7.6(1)	-	-	-0.99	-0.48
P4 posterior cusp length[3]	4.6(1)	-	-	0.81	2.02
P4 crown length[3]	12.4(1)	-	-	0.32	-2.00
			discriminant score =	-14.50[6]	+3.73[6]

[1]Measurements according to Nowak (1979).
[2]Measurements according to and used by both Lawrence and Bossert (1967) and Nowak (1979).
[3]Measurements according to Lawrence and Bossert (1967).
[4]Nowak (1979).
[5]Values obtained using discriminant coefficients as reported by Lawrence and Bossert (1967).
[6]Final score is the result of adding all individual discriminant function values.

for coyote-dog hybrids (34-36%) reported by Howard (1949). Two discriminant scores were generated (Table 1) utilizing fifteen cranial measurements described by Lawrence and Bossert (1967). A discriminant score of -14.50, along the *Canis latrans – familiaris* axis was within the range of values for *C. latrans* as reported by Lawrence and Bossert (1969). A score of 3.73 along the *C. latrans – lupus* axis placed the Prince Edward Island specimen morphologically close to *C. lupus* as reported by Lawrence and Bossert (1969). The Prince Edward Island specimen was smaller for all cranial measurements, except for braincase width and M2 crown width, when compared to values for *C. familiaris* (Table 1). This difference is similar to that expected in a comparison of coyotes to domestic dogs. The Prince Edward Island canid was most similar in cranial morphology to the New Brunswick coyote population with all of its measurement values falling within the value ranges of the latter (Table 1).

The above analyses support a *Canis latrans* classification for the Prince Edward Island canid specimen. However, its morphological similarity to *Canis lupus* suggests hybridization between *C. latrans* and *C. lupus*. The Prince Edward Island coyote emigrated from either New Brunswick or Nova Scotia. Additional *Canis latrans* from Prince Edward Island, New Brunswick and Nova Scotia will have to be secured in order to determine more accurately the systematic relationship between each other and between other North American coyote populations.

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Responses of Snowshoe Hares, *Lepus americanus*, to Timber Harvesting in Northern Maine

ROGER W. MONTHEY

School of Forest Resources, University of Maine, Orono 04469
Present address: Bureau of Land Management, 1717 Fabry Road, Salem, Oregon 97306

Monthey, Roger W. 1986. Responses of Snowshoe Hares, *Lepus americanus*, to timber harvesting in northern Maine. Canadian Field-Naturalist 100(4): 568–570.

Based on winter track counts, Snowshoe Hare (*Lepus americanus*) activity was greater than expected in a commercially clearcut forest, and less than expected in undisturbed and partially harvested forests of northern Maine. Within the commercially clearcut forest, hare activity was greater than expected in uncut softwoods and mixed hardwood-softwood stands. In the partially harvested and undisturbed forests, hare activity was greater in uncut softwoods.

Key Words: Forest harvesting, Maine, Snowshoe Hare, *Lepus americanus*.

Relatively little information is available concerning the effects of commercial forest harvesting upon Snowshoe Hares (*Lepus americanus*) in Maine. Conroy et al. (1979) studied the relationship between Snowshoe Hare activity and habitat components within Michigan clearcuts, and provided a review of previous research. Important components of hare habitat reported for different regions and forest conditions include dense woody vegetation (Adams 1959), vegetation structure (Bider 1961), stem diameter of browse (Keith 1974), continuity of coniferous cover (Brocke 1975), habitat interspersion, and distance to lowland forest cover (Conroy et al. 1979). The objective of this study was to determine forest and cover type preferences in relation to browse availability within a commercially clearcut forest, a partially harvested forest, and an undisturbed forest.

This research was conducted concurrently with studies assessing the responses of Marten (*Martes americana*) (Soutiere 1979), ungulates (Monthey 1984), and small mammals (Monthey and Soutiere 1985) to logging in northern Maine.

Study Area

The study area was near the eastern shore of Moosehead Lake in T1R14 WELS and East Middlesex Canal Grant townships, Piscataquis County, Maine. Detailed descriptions of the three forests examined and their cover types have been presented by Soutiere (1979). Major cover types included softwoods (75-100% conifer crown cover), hardwoods (75-100% hardwood crown cover), mixed softwood-hardwood stands (softwood-dominated, 50-74% conifer crown cover), and mixed hardwood-softwood stands (hardwood-dominated, 25-49% conifer crown cover). Three forests were studied.

The undisturbed forest constituted 13.9 km^2 in 1974, but ongoing timber harvesting reduced the forest to 5.5 km^2 by 1977. Undisturbed forest stands were primarily even-aged. Red Spruces (*Picea rubens*) were 60-200 years old and Balsam Firs (*Abies balsamea*) were about 70 years of age. Canopy density averaged 85-90%.

The partially harvested forest constituted 7.5 km^2 by 1977 and was harvested concurrently with the above forest. Trees were harvested to minimum diameter limits of 15 cm diameter at breast height (dbh) for balsam fir and 40 cm dbh for spruce and hardwoods. The result was a patchy harvest ranging from essentially clearcut areas to scattered areas of non-operable stands left uncut because of diameter limit restrictions. Average basal area was reduced 57-84% compared to uncut stands. Canopy density averaged 60% (18-95%) in softwood stands, and was only slightly reduced in hardwoods.

The commercially clearcut forest constituted 25.7 km^2 and was harvested between 1960 and 1975. Fifty percent of the area was clearcut and 25% selectively cut (or high-graded). Softwood stands were clearcut and only isolated nonmerchantable stands remained uncut. The uncut stands occupied 21% of the forest and consisted of islands within clearcuts or narrow strips along ericaceous bogs, streams, and ponds. Stands adjacent to waterways often had dense ground covers consisting of low, widespread conifer branches and ericaceous shrubs. Mixed and hardwood stands, consisting primarily of Sugar Maple (*Acer saccharum*), American Beech (*Fagus grandifolia*), and Yellow Birch (*Betula alleghaniensis*) were selectively cut, removing most of the merchantable trees. Average basal area was reduced 50% in mixed stands and was little changed in hardwood stands. Clearcuts ranged from 1 to 15 years post-cutting and consisted of dense ground covers of slash and raspberry stems (*Rubus* sp.) in recent stages, with a heavy overstory of sapling Pin Cherry (*Prunus*

pensylvanica) and other hardwoods in addition to softwood regeneration in later stages. Three successional seres of clearcuts were present, including stages 1 to 3, 7 to 9, and 12 to 15 years post-cutting. These stages corresponded with no sapling cover above the snow, scattered sapling cover, and taller, more uniform sapling cover, respectively. Clearcuts ranged in size from two to several hundred ha.

Methods

Habitat use was determined by track counts. I assumed that the occurrence of tracks in winter was indicative of the extent of activity in, and preference for, the harvested or undisturbed forests and the respective cover types. Track counts were conducted along 50 km of permanent lines divided into consecutive 15 m segments. Counts were conducted 1 to 2 days after a snowfall, and as much of the 50 km of lines as possible was sampled on the same day. Track counts were taken on ten days in winter 1974-75, seven days in 1975-76, and five days in 1976-77. Methods of Neu et al. (1974) were used to test for differences in mammal use (or activity) between the different forests and cover types.

The number of hardwood and softwood stems (< 8.9 cm dbh and > 0.6 m tall) on 30 m^2 rectangular plots along the transect lines was recorded as an estimate of winter browse availability. Based on previous work indicating the importance of dense sapling growth to hares, I hypothesized that hare activity was generally correlated with the number of hardwood and softwood saplings extending above the average winter snow depth. The 0.6 m average snow depth was determined by reference to stakes in representative cover types.

Results and Discussion

Browse was more available in the commercial clearcut forest and less available in the undisturbed forest (Table 1). The amount of browse was generally greatest in clearcuts, intermediate in mixed stands, and least in uncut softwood stands. Predominant saplings along transect lines were Balsam Fir, Yellow Birch, White Birch (*Betula papyrifera*), Red Maple (*Acer rubrum*), Pin Cherry, willow (*Salix* sp.), Striped Maple (*Acer pensylvanicum*), and Red Spruce.

Snowshoe Hare use was greater than would be expected by chance in the commercially clearcut forest and less than expected in the partially harvested and undisturbed forests (Table 2). Within the commercially clearcut forest, Snowshoe Hare activity was greater than expected in uncut softwoods and mixed hardwood-softwood stands. Habitats which were used significantly less than expected included 7 to 9 year old clearcuts, mixed softwood-hardwood

TABLE 1. Average density of hardwood and softwood stems (< 8.9 cm dbh and > 0.6 m tall) along transect lines in undisturbed, partially harvested, and commercially clearcut forests in northern Maine.

Forest condition and type[a]	N 30-m^2 Plots sampled	Stems/ha
Undisturbed		
Softwood	46	6 000
Mixed softwood-hardwood	23	13 333
Mixed hardwood-softwood	10	5 333
Hardwood	18	19 333
All types	97	10 143
Partially harvested	20	13 667
Softwood		
Mixed softwood-hardwood	11	8 000
Mixed hardwood-softwood	14	17 667
All types	45	13 253
Commercially clearcut	98	23 333
Clearcut softwood (7-9 years)		
Clearcut softwood (12-15 years)	68	31 667
Uncut softwood	111	7 000
Mixed hardwood-softwood	41	15 667
Mixed softwood-hardwood	80	22 667
Hardwood	34	6 000
All types	432	18 230

[a]Softwood — crown cover 75-100% conifer; mixed softwood-hardwood — crown cover 50-74% conifer; mixed hardwood-softwood — crown cover 25-49% conifer; hardwood — crown cover 75-100% hardwood.

stands, hardwood stands, and roads. Hare activity within the 12 to 15 year old clearcut stage was greater than in younger stages, probably due to the availability of dense, sapling cover. In the partially harvested forest, non-operable softwood stands received greater than expected use, and remaining forest types were used less than expected. In the undisturbed forest, snowshoe hare activity was greater than expected in softwood stands and less than expected in hardwoods.

Snowshoe Hare preference for the commercially clearcut forest probably related to the greater availability of winter browse and increased habitat interspersion compared to the other forests. Within the commercially clearcut forest, hare activity was greatest in areas with high juxtaposition of browse and cover, and least in large clearcuts with little sapling cover above the snow. These observations coincided with findings of Conroy et al. (1979), who reported the importance of habitat interspersion and distance from lowland conifer-hardwood cover to

TABLE 2. Presence of snowshoe hares on 15 m segments of transect lines (totalling 50 km) sampled 1-2 days after a snowfall, Piscataquis County, Maine, 1974-77.

Forest condition and type	N segments sampled	N segments with tracks	% segments with tracks
Undisturbed			
Softwood	2 996	233[a]	7.8
Mixed softwood-hardwood and hardwood-softwood	2 187	105	4.8
Hardwood	1 204	15[b]	1.2
All types	6 387	353[b]	5.5
Partially harvested Softwood	1 714	36[b]	2.1
Non-operable softwood	1 150	357[a]	31.0
Mixed softwood-hardwood and hardwood-softwood	1 325	10[b]	0.8
Hardwood	686	4[b]	0.6
Other[c]-non-operable	291	3[b]	1.0
All types	5 166	410[b]	7.9
Commercially clear-cut Clearcut softwood (1-3 years old)	378	4	1.1
Clearcut softwood (7-9 years old)	2 355	93[b]	3.9
Clearcut softwood (12-15 years old)	1 714	304	17.7
Uncut softwood	3 238	1 117[a]	34.5
Mixed hardwood-softwood	919	228[a]	24.8
Mixed softwood-hardwood	2 012	210[b]	10.4
Hardwood	665	48[b]	7.2
Road	401	57[b]	14.2
All types	11 682	2 061[a]	17.6

[a]Greater than expected, $P < 0.05$.
[b]Less than expected, $P < 0.05$.
[c]Mixed softwood-hardwood, mixed hardwood-softwood.

hare activity in clearcut areas. Hare preference for softwood cover and dense sapling growth observed in my study area has been previously reported (Grange 1932; Cook and Robeson 1945; Brooks 1955; Richmond and Chien 1976). Less habitat interspersion and sapling growth in the undisturbed and partially harvested areas presumably made these areas less attractive to hares.

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Comparison of the 1984 Aquatic Macrophyte Flora in Lake Temagami, Northern Ontario, with the Flora Published in 1930.

H. M. DALE

Department of Botany, University of Guelph, Guelph, Ontario N1G 2W1

Dale, H. M. 1986. A comparison of the 1984 aquatic macrophyte flora in Lake Temagami, northern Ontario, with the flora published in 1930. Canadian Field-Naturalist 100(4): 571–573.

No identified aquatic macrophyte species has been lost from the flora during the past fifty-five years in spite of acid precipitation during this period. Lake Temagami is 90 km NE of Sudbury, a centre of nickel and copper extraction. Fifteen clearly identified sites were studied using snorkel equipment. Eight species of submersed and floating-leafed plants were added to the 1930 list. Two of these were large in size and locally abundant — *Potamogeton robbinsii* and *Megalodonta beckii*. Their previous omission may have been due to their non-flowering state or due to the method of plant collection. This 1984 study provides quantitative data which may provide a base for future study.

Key Words: Aquatic plants, freshwater lake, macrophyte, flora, acid precipitation, Ontario.

The perceived effects of acid precipitation falling on the Lake Temagami watershed from the Sudbury smelters 90 km to the southwest have upset residents and visitors for many years. As a result, in 1971 the Temagami Lakes Association (an organization of about 550 permanent residents, owners of lodges, cottages and camps) formed a committee to study the effects of SO_2 (sulphur dioxide) pollution (Bangay[1]). This was followed by the measurement of some physical and chemical parameters in lake waters (Conroy et al.[2]) and in waters of adjacent areas (Conroy and Keller[3]). These data, though valuable as such, cannot be extrapolated back to the conditions prevailing prior to the period of active SO_2 emission when baseline studies were not made. These measurements, collected in a relatively short time as indicators, cannot accurately reflect changes in the lake if data for comparison are not known.

If, however, it can be assumed that those submersed plants whose life is intimately connected with the waters of the lake would be most influenced by changes therein, then a comparison of the flora now present with that known in 1930 could indicate trends. This early flora was part of a project to collect, over several years, all the larger plants present in the Temagami Forest Area. Pressed and dried specimens of most of the aquatic plants listed by Krotkof[4] were examined by the author in the herbarium of the University of Toronto (TRT). It was anticipated that the collection sites could be revisited in 1984.

[1]Bangay, C. 1973. The dragon's breath. Alternatives (Trent University), Winter, 37–47.

[2]Conroy, N., W. Keller, and A. Bangay. 1974. The water quality of Lake Temagami. Ontario Ministry of Environment. 46 pp.

[3]Conroy, N., and W. Keller. 1974. A report on a biological survey of the waters receiving wastes from Sherman Mine, Temagami, Ontario. Ontario Ministry of Environment. 42 pp.

[4]Krotkof, P. V. 1930. (Untitled) Collections from Temagami forest reserve, text and check list. 2+14 pp.

Methods

At each of 15 sites, areas of 300 m² were examined by the author snorkelling through the vegetation in August 1984. An abundance rating (0 to 4) was assigned to each submersed and floating-leafed species (Table I). Specimens were collected and later pressed and dried. These are deposited in the herbarium of the University of Guelph (OAC). The sites were chosen close to the collection areas identified in the 1930 report. Unfortunately, the map part of the report was not available. Locations designated as Epilobium Bay and Solidago Point on herbarium sheets were valueless. Not all specimens in the herbarium were on Lake Temagami. *Elodea* and *Vallisneria* (common names in Table 1) were from Marten River within the Temagami forest. In this nutrient-poor lake the vegetation along most shores was depauperate so sites were located in shallow, sheltered bays where detritus was lodged after being carried downstream or wind-borne. The location of these sites (Table 2) is designated using the number assigned to the nearest island. There are 1259 islands of sufficient size to be numbered on map 24c of the Ministry of Natural Resources, Ontario.

Results

There was no evidence of the loss of any plant species from Lake Temagami (Table 1). The single species from Krotkof's list not found in 1984 was

TABLE 1. Plant species present on Krotkof's list of 1930 and ratings of abundance at sites surveyed in 1984. A blank indicates absence. Abundance ratings: √ present; 1 rare; 2 occasional; 3 common; 4 abundant; + voucher. Nomenclature follows Gleason and Cronquist (1963) and common names are from Fassett (1957).

Site (see Table 2)		Krotkof	1	2	3	4-5	6	7	8	9	10	11	12	13	14	15
Chara globularis	Stonewort				1	2	2		2+	2						
Nitella flexilis	Nitella				3								2+			
Isoetes echinospora	Quillwort	√	2+				1	2	1	1	2		2		1	
Sparganium angustifolium	Floating leaf burreed	√	2	2	2	1		3+	3	2	2	2		1	1	
S. fluctuans	Broad ribbonleaf	√						2+				1		1+		
Potamogeton alpinus	Red pondweed											2+				
P. amplifolius	Largeleaf pondweed	√			2+	2	1	2+						1	1	
P. confervoides	Alga pondweed		1		1											
P. epihydrus	Ribbonleaf pondweed	√	2	1	3	1			2	2						
P. gramineus	Variable pondweed	√	2+			2		2+	2			2	2		2	1
P. natans	Floating brownleaf	√		3+					2	2	2	1	2			
P. oakesianus	Oakes pondweed	√			1											
P. praelongus	Whitestem pondweed													1	1+	
P. pusillus	Small pondweed	√	2+				1	2+								
P. richardsonii	Claspingleaf pondweed	√			2		2	2+								
P. robbinsii	Robbins' pondweed		2+					3+	1+	1			3			3
P. spirillus	Pondweed	√	2		1+	1			2+	2		2+		1		
Najas flexilis	Slender naiad	√	1				2	3	2+	2		2		1		1
Sagittaria cuneata	Northern arrowhead	√						2			2	2	3			
S. graminea	Arrowhead	√										1				
Elodea canadensis	Waterweed	√														2+
Vallisneria americana	Tapegrass	√											2+			
Eleocharis acicularis	Needlerush	√	1+		2+	2		3	2+	2	2	2	2			3
E. robbinsii	Triangle spikerush	√	2+		2				2+							
Scirpus subterminalis	Water clubrush	√										3	1		2	
Eriocaulon septangulare	Pipewort	√	2		2		2	2+	2		2			1	3	4
Brasenia schreberi	Watershield	√					1		3	2+	1		2			
Nuphar variegatum	Spatterdock	√	2	2	1			2	2			1			1	
Nymphaea odorata	Fragrant waterlily	√		1	1			2	3		3	3				
Ranunculus trichophyllus	White water buttercup	√						2+								
R. flammula	Creeping spearwort	√							1		1	1				
Callitriche verna	Water chickweed											1+				
Hypericum boreale	Northern St. John's-wort										2			2		
Hippuris vulgaris	Mare's tail	√										3+				
Myriophyllum alterniflorum	Small watermilfoil	√	2				1	3+		2	2					
M. exalbescens	Northern watermilfoil	√								2+						3
M. tenellum	Watermilfoil	√			2			2+			2					
Lysimachia terrestris	Swampcandle	√									2					
Veronica catenata	Water speedwell	√									2					
Utricularia cornuta	Bladderwort	√														
U. gibba	Eastern bladderwort							1+			1					
U. intermedia	Flatleaf bladderwort	√										1+		1		
U. vulgaris	Common bladderwort	√						2+	1	2		1		2		
Lobelia dortmanna	Water lobelia	√					1	2+	1	1	2			1	2	
Megalodonta beckii	Water marigold							3+					2+			

Utricularia cornuta, which is a subterranean species whose flowers appear above water only at certain times of the year. In the vegetative condition, without flowers, it is difficult to see or recognize. There were eight vascular plant species found in 1984 not on Krotkof's list.

Discussion

The collections made between 1923 and 1930 were to complete an inventory of all vascular plants within the Temagami Forest. The aquatics collected were only part of the major study. The 1984 study, on the other hand, concentrated only on species which had an intimate association with the water column. Efficient use of time was possible with snorkel and flippers to move through the vegetation. Table 1 does not list the complete flora of the lake but it shows few changes in areas close to those previously sampled.

The only species missing, *Utricularia cornuta*, was also overlooked in two of eight Muskoka lakes resurveyed in 1977. On the other hand, the underwater sampling using SCUBA revealed large amounts of *Potamogeton robbinsii* (not seen in 1953) in one other lake. The addition of such deep water species by improved sampling methods and the decline of floating-leafed species from greater human use of waterways had produced differences in the two sets of data from the Muskoka Lakes (Miller and Dale 1979).

A decrease in the abundance of yellow water lily, *Nuphar*, in an isolated island lake was attributed to beaver activity whereas opportunistic species such as *Megaladonta beckii, Eriocaulon*, and *Callitriche*, unknown in 1926, were rated as common, locally abundant, and abundant, respectively, in 1982. These

TABLE 2. Location of sites on Lake Temagami, Nipissing District, Ontario. Numbers are for Map 24c Islands of Lake Temagami, District of Nipissing, Ministry of Natural Resources, Ontario (1 inch = 1 mile).

Site #	Closest Island	
1	794	Portage Bay, deep in north east bay
2	792	Portage Bay, mouth of north east bay
3	776	West of Pelican Point, north facing bay
4	314	High Rock Island, south facing bay
5	321	North of High Rock Island, east facing bay
6	291	Shinningwood Bay, bay east of Denedus Island
7	257	Shinningwood Bay, east end, creek mouth
8	1044	Kokoko Bay, bay on east side
9	1050	Kokoko Bay, bay and creek mouth, west side
10	1033	Mule Bay, north end
11		Outlet Bay, mouth and creek from Aileen L.
12	962	Outlet Bay, south facing bay
13		Outlet Bay, west side, creek mouth
14	819	Cross Bay, middle of east end, creek mouth
15	183	Northeast Arm mouth, Marina docks in north facing bay

Potamogeton robbinsii (not seen in 1953) in one other lake. The addition of such deep water species by improved sampling methods and the decline of floating-leafed species from greater human use of waterways had produced differences in the two sets of data from the Muskoka Lakes (Miller and Dale 1979).

A decrease in the abundance of yellow water lily, *Nuphar*, in an isolated island lake was attributed to beaver activity whereas opportunistic species such as *Megaladonta beckii, Eriocaulon*, and *Callitriche*, unknown in 1926, were rated as common, locally abundant, and abundant, respectively, in 1982. These were thought to have become widespread when water levels fell after beaver activity ceased (Dale and Garton 1984). *Megalodonta beckii* had been rated as abundant in Whitewater Lake (near Sudbury) in 1947 but was not found at any of the 22 sites surveyed thirty years later. This species has been found to decrease in abundance, often to extinction, with pollution and eutrophication in several studies (Dale and Miller 1978). From this study of Lake Temagami there is no evidence for acid precipitation changing the composition of the aquatic flora during the past 50 years. The lack of earlier, more precise quantitative data for comparison precludes a clear conclusion. Changes in abundance of species may have occurred during the fifty-five year interval but it is not possible to address this aspect. The 1984 quantitative data from designated sites will provide a baseline for future studies.

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The author wishes to thank the Temagami Lakes Association for their interest in this study, and particularly C. Cochrane for giving so much valuable time in discussions and for providing expert guidance to the sites sampled.

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News and Comment

1985 Honorary Memberships and Ottawa Field-Naturalists' Club Awards

Once again Awards Comittee recommended, and Council approved, two new Honorary Members, bringing the total to twenty-two. It will be recalled with regret that Dr. Bernard Boivin, a 1983 Honorary Member, passed away during 1984.

All five of the established Ottawa Field-Naturalists' Club awards were awarded for 1985 as well as, for the first time, our new President's Prize. This prize was approved by Council in January. It is considered an annual award, and is to be given by the President to the Club member who in his opinion stands out for effort, accomplishment, or activity not otherwise covered by the official OFNC awards. The recipient is to be chosen by the President alone, based on his knowledge of the year's accomplishments. The citation for the first of these prizes is included here. Presentation was made by Frank Pope, President during 1985.

Award winners were identified and citations read by President Bill Gummer at the Soirée: unfortunately only three recipients were able to be present. Citations are reproduced below.

Honorary Members:

Dr. Edward Lloyd Bousfield, FRSC

Dr. Bousfield is a nationally and internationally known and respected zoologist who has been connected with the National Museum of Natural Sciences since the early 1950s. The Club is pleased to include him in its roster of Honorary Members.

He obtained his M.A. from Toronto and his Ph.D from Harvard, in the same period gaining experience in both freshwater and marine biology. He actually joined the Museum before completing his doctorate and his career has brought him to the position of Senior Scientist. He has maintained the major focus of his research on coastal marine invertebrates, especially crustaceans and molluscs of Canadian and adjoining waters of North America. His special interest, however, has long been the amphipods, tiny animals found in virtually every habitat of the world. They are of importance not only as a major food source for higher organisms, but also because some forms can attack wood and even concrete. His work on these invertebrates has pioneered the way to proper understanding of their evolutionary history.

As a result of his studies, it is now possible to consider some amphipods as pollution indicators (since their requirements are so precise that even a small and intermittent pollution can be detected), and others as a tool in waste disposal (since they are voracious and may have non-specific tastes).

His knowledge in the field is widely recognized throughout the scientific world, and he has given invited papers at meetings in the United States, Poland, Russia, Israel, and Germany. He has held positions at other institutions, including Senior Visiting Investigator at the Woods Hole Oceanographic Institute, and Research Associate at Sapelo Island in Georgia. He has held university teaching positions in Canada and the United States. His publications are numerous, nearly 100, and include several in *The Canadian Field-Naturalist* and *Trail & Landscape*. He beat us to Trinidad — where our twin Club operates — with a paper in the Trinidad Field Naturalist publication on terrestrial amphipods in 1957.

With all that, Dr. Bousfield has been a prominent OFNC member, joining in 1951, Councillor from 1953 to 1969, and President 1958-1960. He has been an Associate Editor of *CFN* since 1969.

Dr. Claude E. Garton

Despite its vast size and the importance of its resources, the flora of the Boreal Forest of Canada has not been well studied. Few areas have been intensively collected in and fewer yet have received continuing botanical attention over a period of years. This is certainly the case in northern Ontario. Our knowledge of much of northwestern Ontario in particular would be exceedingly poor, were it not for the collecting efforts of Claude Garton.

Dr. Garton has been an active and prolific collector of vascular and non-vascular plants in northern Ontario since the early 1930s. The strongest representation of his material is from the Thunder Bay area where he has been a resident since 1928. A career as a public school teacher and principal (he retired in 1966) enabled him to apply the summer months to his botanical interests and he travelled throughout the north of the province doing so. In over fifty years of activity he has made thousands of collections, most accompanied by a number of duplicates which have

been distributed to major collections throughout Canada. These sets of collections are often the basis for the northern Ontario collections at these institutions. His collections are well prepared and, very importantly, are accompanied by detailed label data that clearly locate and describe the situation and habitat of the collection.

In 1967, Dr. Garton donated 14 000 specimens to Lakehead University in Thunder Bay; over 25 000 duplicates of these collections have also been distributed. He has served as the curator of the university's herbarium since that time and has brought it to a point where it now contains over 76 000 specimens. It was renamed the 'Claude E. Garton Herbarium' in appreciation of his contribution to the university and to northern Ontario botany.

Dr. Garton has published relatively little, preferring to leave the reporting and analysis to others, but is mentioned in innumerable sources through his collections. He has also played an active role in conservation efforts in northwestern Ontario and has been an enthusiastic and inspirational motivator for many new, young botanists at Lakehead University and in the Thunder Bay area.

Lakehead University conferred an Honorary Doctor of Science degree upon him in 1979, and he has received a number of other tributes for his work from various local and provincial organizations. Dr. Garton has been a member of the OFNC since 1945, one of our long-time members.

Claude Garton has personally uncovered over forty first records for Ontario and has offered a record of achievement in the study of the botany of Ontario that is unmatched anywhere in the north. His work will help to serve our need for botanical information in Ontario for many years to come.

MEMBER OF THE YEAR

Ellaine Dickson

613-772-3050 — What does this telephone number mean to you? To many, the voice that answers this number is their first contact with The Ottawa Field-Naturalists' Club; to others, it is the source of information on a multitude of subjects, a contact for trips, a friendly voice that speaks for us and to us. Ellaine Dickson has manned our Club number since its installation in early 1978, a demanding task carried out efficiently and with finesse.

She joined the Club in 1968, and since 1978 has been a member of Council and has served on several committees, currently Nominations, Membership, and Excursions and Lectures. She is usually on the job at events to greet newcomers and to co-ordinate activities so that everyone has a successful time.

Ellaine has a broad knowledge of the world about her and her enthusiasm and generosity in sharing this knowledge is well known. Many of us call her a "walking resource". She is always in demand as leader for outings on birds, mushrooms, wild flowers, trees and shrubs.

We are proud of her ability as an artist and carver. Her bird carvings have been used as presentation pieces for the Anne Hanes Natural History Award, for example.

Ellaine received the Club's Service Award for 1981, the first year of our present group of awards. Now she is Member of the Year and we hope that this reflects her behaviour as a sort of member of every year, as well as our public recognition of her value.

SERVICE AWARD

Eileen Evans

The presentation of the 1985 Service Award is a real pleasure. It is given to Eileen Evans, who in all of her activities contributing to the smooth working of the Club has been respected for her reliability and the high quality of her output.

If you immediately think of refreshments after monthly meetings when you hear her name, quite correct. However, she has acted as a sort of caterer-coordinator-scheduler not only for those meetings but also for our Soirées, our picnics, and other meetings. She has made sure that in such social get-togethers there were always enough of the various things required, and at the proper place and time.

Eileen has also been involved with *Trail & Landscape* since 1977 when she became a proofreader, and until 1980 she worked on Anne Hanes' copy of each issue before it went to printing. Since then she has continued as a member of the proofreading team for the camera-ready copy.

She is a hardworking member of the Excursions and Lectures Committee, a committee responsible last year for the organization of some 60 tours and trips, 10 monthly meetings, the picnic and the Soirée. She has also provided liaison and coordination with the Rideau Trail Club (of which she has been on the Executive) for our joint trips.

Eileen, who joined in 1974, is a real full member of the OFNC, participating very actively in trips and using everything the Club has to offer. To Eileen, our sincere thanks and our 1985 Service Award.

CONSERVATION AWARD

James M. Richards

Since his school days in the 1950s, Jim Richards has been a keen and expert birder and active naturalist in the Oshawa, Ontario, area. He is an accomplished bird photographer. In 1974, Jim co-authored the acclaimed *Birds of the Oshawa-Lake Scugog Region*

with R. G. Tozer and is presently involved in a revision and expansion of that study.

Jim's interest in conservation arose through a concern for the threat to important birding spots in his home area from expanding industrial and urban development. Foremost in his mind has been the Second Marsh, one of the few remaining cattail marshes that once dotted the north shore of Lake Ontario. It was here in 1962 that the first North American nesting of the Little Gull, a Eurasian species, was discovered. The Second Marsh remains an important wetland habitat for many other species as well.

The Second Marsh was slated for obliteration by the federal government to make way for a new port for the City of Oshawa and immediately Jim Richards took up the fight to save it. For the next *twenty* years he doggedly pursued politicians, the media, public servants and the general public in an effort to gain support for the protection of the marsh. He was instrumental in the establishment and continuance of the Second Marsh Defence Association (of which the OFNC was a member organization). Finally, in 1985, Jim and his associates received the long-awaited news that the federal government was no longer interested in the marsh as a harbour area and that it wished to see it developed as an ecological reserve. While the details of final ownership and the precise manner of management have yet to be finalized, it appears that two decades of effort have really paid off.

We award the 1985 Conservation Award to OFNC member Jim Richards in recognition of his pivotal role in the persistent and inspirational battle to save the Second Marsh. We need more Jim Richards and more such tireless efforts all across Canada if we are to save other important natural areas from needless destruction.

Anne Hanes Natural History Award

Ross Anderson

Award requirements for the Anne Hanes award have not been met every year so it is gratifying to honour Ross Anderson this year.

Ross has been a Club member since coming to Ottawa in 1981. He is an architect by profession and is in charge of training programs in connection with historic sites, Parks Canada.

He has always had an interest in drawing and a love of nature. The combination of these interests, along with considerable talent has resulted in a series of fascinating articles in *Trail & Landscape*. These articles, beautifully illustrated and a joy to read, have appeared with regularity since the November-December issue in 1982. They have covered natural history topics of the Ottawa Valley, ranging from mushrooms, wild flowers and edible wild plants to birds.

Ross has a gift for focussing on common things which surround us and opening our eyes to their uniqueness and beauty. He shows them to us in a new light, often with a touch of whimsy.

Because he has contributed so much to the understanding and appreciation of local natural history, and has exposed the wonder and delight to be found in our immediate environment, and because we hope there will be many more contributions to come, it is fitting to honour Ross with the Anne Hanes Natural History Award.

President's Prize

Christine Hanrahan

The first of the new President's Prizes was given for the year 1985, the year in which the *Ontario Breeding Bird Atlas* project was successfully completed.

The project got underway in the assigned Ottawa sector with enthusiasm, but after two years it was clear that effort needed to be increased. Bird watchers responded to the challenge. Those involved rededicated themselves and others volunteered to assist. From this critical period the quiet influence of Christine Hanrahan in organization and communication became increasingly evident.

She identified areas that needed strengthening; she applied for funds to help with travel costs. Groups were organized to cover difficult-to-access or under-represented areas. Special routes were designed to pick up nocturnal species. At the end of the project, she verified the input from the Ottawa sector to the provincial database. Also at the end, the area involved had been increased by nearly 50% by inclusion of adjacent squares from other sectors.

For her valuable contribution to this work, Christine received the President's Prize from Frank Pope.

1987 Annual Meeting: Colonial Waterbird Society

The 11th Annual Meeting of the Colonial Waterbird Society will be held at the Red Oak Inn in Thunder Bay, Ontario, 10-13 September 1987. Lynn Hauta and John P. Ryder are in charge of local arrangements. Announcements of the schedule and call for papers will be mailed at a later date.

JOHN P. RYDER
Chairman, Local Committee

Department of Biology, Lakehead University, Thunder Bay, Ontario P7B 5E1

Errata

Note that in *The Canadian Field-Naturalist* 100(3) two figures are reversed in *each* of two articles by Daniel F. Brunton. In "Status of Southern Maidenhair Fern" the photo on page 407 should appear over the caption (Figure 1) on page 405 and the photo on page 405 should appear over the caption (Figure 3) on page 407. In "Status of the Mosquito Fern" the photos over the captions for Figures 1 and 2 are reversed on page 410.

FRANCIS R. COOK
Editor

Book Reviews

ZOOLOGY

Birds of Orkney

By Chris Booth, Mildred Cuthburt, and Peter Reynolds. 1984. The Orkney Press, Stromness, Orkney. xxv + 272 pp., illus. £12.

Some years ago I accepted an invitation to visit the Orkneys and join a short expedition to band British Storm Petrels. Orkney, as I discovered, is a charming collection of islands to the north of Scotland. The names of the islands and indeed many of the unusual words used by the Orcadians reflect their Viking past. Sule Skerry, Linga Holm and Flotta are good examples. Even today Orkney has a maritime Viking atmosphere. But for the bird watchers the attraction is seeing seabirds in a way that is not possible further south. Great Skua, Parasitic Jaegers and Red-throated Loons all breed here. For those of us used to seeing the occasional jaeger, it is a marvelous experience to be dive-bombed on their breeding ground.

Birds of Orkney is one in a series of books about various aspects of the Orkney Islands. The book begins with a brief description of Orkney's geography and of each of the individual islands. There is also a brief comment on the factors influencing bird distribution. The following 250 pages are then devoted to the systematic list. The authors are to be commended for their painstaking effort in searching through previous records. This was clearly an arduous and often frustrating task. There are several species that have been reported as occurring in Orkney for which no suitable documentation is available to substantiate the record. Some of these records are really quite old. But it is problems like this that should inspire those who keep club and original records to maintain adequate documentation for posterity.

In general, Orkney has only a small number of resident, breeding, or regularly occurring birds. A very large percentage of Orkney's list is made up of vagrants. These rarities have arrived from the far corners of the world: Bee Eaters and Orioles from the south, Bridled Terns from the tropics, Nighthawks and a Yellow-billed Cuckoo from the Americas, and Owls from the north. Precise information is given for each of these sightings.

Furthermore, for the common birds, the authors have included seasonal distributions, population densities, or breeding statistics, as appropriate. Particular attention is paid to those birds which can be considered Orkney's "specialities", like the Skuas, Jaegers, and breeding shore birds.

The book is illustrated with black and white photographs of birds and a small number of colour photographs of scenery. There are also a number of delightful bird drawings scattered throughout by artist John Holloway.

The book closes with a short but interesting account of bird evidence found at prehistoric archeological sites. The sites themselves are interesting and provide yet another incentive to visit Orkney. The bones found include those of White-tailed Eagles and Great Auks – birds no longer found on Orkney.

The book is well written, well organized and has a satisfying amount of detail. The text, photographs, and drawings combine to give a real flavour of these fascinating northern isles. For the ardent birder this book is well worth the money to get an understanding of a unique habitat. For example, the mean summer and winter temperatures are 13°C and 4°C respectively! This has a profound effect on vegetation and hence the whole ecology of the region. This informative book will give you many such details and create a vivid mental picture of Orkney and its bird life.

ROY JOHN

8 Aurora Crescent, Nepean, Ontario K2G 0Z7

Birds of Nahanni National Park, Northwest Territories

By George W. Scotter, Ludwig N. Carbyn, Wayne P. Neily, and J. David Henry. 1985. Saskatchewan Natural History Society Special Publication Number 15. 74 pp., illus. $7.00.

This book, the fifteenth in a series of special publications started in 1958 by the Saskatchewan Natural History Society, is the first to deal entirely with an area outside the province. It covers a small portion (4760 km^2) of the extreme southwestern corner of the Northwest Territories which includes the Flat and lower South Nahanni river systems. The area is remote, little known biologically, and in 1972 was formally established as Nahanni National Park. According to the authors, the primary purpose of this pocket-sized publication is to "provide information on birds of the park".

This volume contains a series of short sections, including a description of the park and its climate, methods, terminology, a discussion of important findings, literature cited, sources of additional information (e.g. books, films and maps) and a checklist of birds for use by visitors to the park. Over half the publication, however, is taken up by two major sections.

The first, and most useful, includes a summary of systematic bird surveys carried out in the summer of 1976 and 1977 in 14 habitat types in the vicinity of Deadman River and the confluence of the Flat-South Nahanni rivers. The difference in number of species (83 versus 68) between the two areas is attributed to greater habitat diversity (mostly mixed woodlands) along Deadman River. White-winged Crossbill (the attractive cover illustration), Yellow-rumped Warbler, and Boreal Chickadee were the most common species in the Deadman River area while Gray Jay, Gray-cheeked Thrush, and Tennessee Warbler were commonest in the Flat-South Nahanni river census unit. Only Dark-eyed Junco was common in both areas.

The second major section, the largest, includes an annotated list. Sources of information include observations by parks staff (mostly the authors) during the summers of 1970 to 1977, published and unpublished reports, and records from park visitors. Accounts for 156 species known to occur in the park contain information on seasonal status, breeding status and frequency of occurrence. Another 12 species (not 14 as indicated in Table 5) are considered hypothetical. These species require confirmation since their occurrence is based on "a single sight record by a single observer". I question whether Mountain Bluebird should be included here because it is the only species without any sort of documentation (see Kraus 1968).

Accounts range from one sentence on the White-rumped Sandpiper to nearly one-third of a page for Hammond's Flycatcher. The longer accounts contain documentation for rare species (e.g. Swainson's Hawk), references for first records for the Northwest Territories (e.g. Hammond's Flycatcher), and a summary of details for breeding species (e.g. Trumpeter Swan).

Noteworthy findings include extensions of breeding ranges for 10 species, four of which (Trumpeter Swan, Barrow's Goldeneye, Golden-crowned Sparrow, and Violet-green Swallow) are apparently first records for the Northwest Territories. Another six species (Wandering Tattler, Barred Owl, Clark's Nutcracker, Philadelphia Vireo, Black-throated Green Warbler, and Mourning Warbler) represent first occurrence records, although Hammond's Flycatcher is mentioned as such in the main list but overlooked in the "Discussion". I am surprised that two species considered hypothetical, Barred Owl and Clark's Nutcracker, are listed among the "first published records" for the Northwest Territories.

This book would perhaps be better if the authors had confined their efforts to summer birds since information is quite incomplete for the migration periods and almost non-existent for winter. In an effort to be complete the data base is pushed beyond its limits. This leads to inconsistency and, at times, conjecture.

For instance, although records are lacking from September to December it is assumed that the Great Horned Owl is an "uncommon permanent resident . . .". A status should either reflect what is known or be qualified with words such as "probably" or "possibly" (see Downy Woodpecker, Three-toed Woodpecker, Black-capped Chickadee). Otherwise readers must search each account for the true status of the species. In addition, the status of the Osprey (single record by a single observer) should be "hypothetical", not "rare summer resident, possibly breeds".

The absence of observers during the migration periods has led to speculation about some species. Although single records are mentioned for Lapland Longspur and Snow Bunting, each species has been assigned a different status. The former is considered "Probably a common migrant" while the latter is listed as a "Rare migrant".

Publications containing annotated lists are important references in works dealing with the distribution of birds, at regional and even national levels. In fact, Godfrey (1966) has relied on other publications in this same series (see Houston and

Street 1959; Belcher 1961; Nero 1963) for his accounts of birds in Saskatchewan. It is very important, then, that authors of such books establish high standards of accepting and documenting records and assuring that significant ones (e.g. specimens, photographs) are preserved before they are published. For these reasons, *Birds of Nahanni National Park* will be of limited value to most ornithologists.

The following examples may help illustrate some of my concerns. Lapland Longspur (probably a common migrant) and Hoary Redpoll (probably a common winter resident) have been included in the park's avifauna on the basis of a simple list of species, all without supporting details, published by Kraus (1968). The list was prepared by a 14 year-old boy who lived near Nahanni Hot Springs and submitted to the editor of *Blue Jay* who rearranged the order and published it in the "Junior Naturalists" section of that journal. In addition, the first record of the Rosy Finch (*Leucosticte arctoa*) for the Northwest Territories was casually accepted from the same list. More surprising is that the authors were aware of the inexperience of Kraus when they suggested that the Loggerhead Shrike on his list was probably "erroneously recorded" and most likely was a Northern Shrike.

Other species have been added to the park list on the basis of what I would consider inconclusive evidence. Pied-billed Grebe, for example, was reported twice — "Two individuals . . . were heard calling . . ." and ". . . one bird considered to be a Pied-billed Grebe was seen disappearing into dense vegetation . . ."– yet the species is listed as "rare summer resident, probably breeds".

Authors of publications dealing with the distribution and abundance of birds in the Northwest Territories have an avalanche of reports to consult that resulted during the early 1970s from studies associated with resource development. Unfortunately most of these remain unpublished and filed in government offices, although a few are now appearing in the published literature (see Salter et al. 1980). It should be mentioned that one such report (Campbell 1973), of interest to this review, lists the first breeding record of Trumpeter Swan for the Northwest Territories, namely a brood of three young was located near Moose Channel, northwest Mackenzie Delta in July 1972.

The scientific value of the book, however, has been enhanced by two significant photographs. One shows a Sora nest and eggs which documents a western breeding range extension and the other illustrates northern nesting habitat for the rare Upland Sandpiper. It is likely these photographs would have remained unknown, or become lost, as few authors make the effort to assure that significant photo-records are deposited and preserved in museums or other established repositories (see Campbell and Stirling 1971). At least two other unpublished but important photographs, Trumpeter Swan (now second breeding) and Wandering Tattler (first occurrence), should be deposited somewhere (e.g. park headquarters; National Museums of Canada) for safe-keeping.

Pages five and six, which I assume include the Table of Contents and List of Tables and Figures, are missing from my copy. Other minor criticisms include inconsistency in the use of upper and lower case letters (see Breeding Status) and location of page numbers (see pages 66, 67 and 71). Also, I am convinced that the names of observers should be listed for all records. These make dull reading and are of little scientific value unless, of course, the records are significant.

Despite my criticisms there is a lot of useful information in this book. Ornithologists will have to carefully sift through and evaluate records in each account before they can use the information. The book will be most useful, however, to people visiting the park. It is attractive, reasonably priced, and will encourage serious amateurs to contribute their observations to fill in gaps in the park's avifauna. The Saskatchewan Natural History Society is to be complimented, and encouraged to continue their contributions to the natural history of remote areas in the central portion of Canada.

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R. WAYNE CAMPBELL

British Columbia Provincial Museum, Victoria, British Columbia V8V 1X4

Biology of Chrysopidae

Edited by M. Canard, Y. Séméria, and T. R. New. 1984. Dr. W. Junk Publishers, The Hague, The Netherlands. x + 294 pp., illus. Dfl. 150.

This book is an excellent account of the biology of the family of insects known as green lacewings. It is the collaborative effort of 22 authors from around the world, under the fine editorial guidance of Canard, Séméria, and New. Each of the authors, including the three editors, has contributed to one or more sections in the area of their expertise. The work is divided into six chapters dealing with virtually every aspect of chrysopid biology, and two chapters devoted to sampling techniques and biological and integrated control.

The first three chapters review the current state of knowledge of the systematics of the Chrysopidae, with contributions from paleontology, morphology of all life history stages, cytogenetics, and electrophoresis. T. R. New presents a compelling case for the need for a world revision of the family. The fourth chapter is the longest and covers every aspect of the life histories of the better-studied species. Examples of variations in the life histories among less well known species are provided, as well. Contributions include the hatching of larvae from eggs, rate of growth, feeding and mating behavior, reproductive physiology, and oviposition. The final contribution in this chapter, by L. M. Miller, is a fascinating account of how the common species *Chrysoperla carnea* hears the cries of hunting bats and takes evasive action to avoid being eaten. Marvelous stop action photographs illustrate the usually successful evasive behavior of flying lacewings, and the consequences of unsuccessful behavior. The fifth chapter reviews the geographical and ecological distribution of chrysopids, and the sixth chapter treats natural enemies. A key is provided to the parasitic Hymenoptera that are known to infest different life history stages of green lacewings. Chapter 7 is a discussion of the methods and difficulties of quantitative sampling of chrysopid populations. The final chapter deals with the large-scale rearing of lacewings and their use in biological and integrated control programs. It is the potential of green lacewings, predaceous as larvae and as adults on a wide range of insect and mite pests, to serve as natural control agents in regulating the populations of agricultural pests that has generated so much study of the group. However, I believe that anyone who reads this book will develop a fascination for these insects that goes beyond their potential utility. This is one of the most interesting recent books on the biology of an insect group that I have read. It is well written, well illustrated, and thoroughly informative. I highly recommend *Biology of Chrysopidae* to anyone with an interest in the natural history of insects.

CHARLES R. PARKER

National Park Service, Uplands Field Research Laboratory, Great Smoky Mountains National Park, Gatlinburg, Tennessee 37738

A Dictionary of Birds

Edited by Bruce Campbell and Elizabeth Lack. 1985. Published for The British Ornithologists' Union by Buteo Books, Vermillion, South Dakota. xxx + 670 pp., illus. U.S. $75.

In 1896, Professor Alfred Newton published *A Dictionary of Birds* which became one of the most prestigious ornithological publications of the first part of this century. It was not until 1964 that a similar work, compiled by the British Ornithologists' Union under the outstanding editorial direction of Sir A. Landsborough Thomson, *A New Dictionary of Birds*, became available to biologists, ornithologists, and bird watchers. As a result of the rapid progress in biology and ornithology, parts of this landmark reference became obviously out of date a few years afterwards. Furthermore, the work has been out of print for many years even after a second printing in 1965.

Again, the British Ornithologists' Union promoted the preparation of what is now more than a new edition of a previous work by enlisting two very capable editors. Nearly 300 specialists from many parts of the world (29 countries) have contributed more than one million words. Contributions from these specialists form "articles on general subjects relating to birds, and on different kinds of birds mainly treated by families". These articles are arranged in alphabetical order "with cross-references . . . so that the dictionary constitutes its own index".

A table of classification (pp. xi — xvii) is provided and incorporates many of the recent changes in classification, except the significant ones provided by the A.O.U. Check-list (1983), which became available

after it was too late to incorporate those important changes in the present work. A detailed list of contributors (pp. xix — xxx) gives the initials of each author as they appear after each entry, their full names, university degrees, honours, affiliation, and the title(s) of the article(s) they have authored. Each entry varies much in size, from a few words which refer the reader to another entry to an article varying in length from a short paragraph to several pages of text. Many entries are illustrated with photographs of good quality, drawings, graphs, or diagrams, which are in all cases clear and concise, and illustrate pertinently important points. Many of the entries are followed by a short list of references which can be very useful to the reader who is looking for additional material on a given subject or for the original citations. All the articles are succinctly written but easy to understand and packed with information.

When an English bird name appears in the alphabetical sequence, it is followed by its Latin name and the section where additional information could be obtained is given clearly in bolder print. Orders, families, and sometimes genera are treated in a similar manner. In some cases (e.g. Dipper), particularly when a name is applicable to a small group of birds, the treatment is extensive and covers all aspects including general characteristics, habitat, distribution, ecology, and behaviour.

The detail of information in the longer entries is no less than encyclopaedic. I have checked or used as references several of them since I have had access to a copy of the *Dictionary* early in the fall of 1985 and each time I have been very impressed by the amount of information which could be included in such a compact text; and yet, readability and accuracy have been maintained throughout without compromise.

The artists have produced excellent black and white illustrations which have as a common denominator their high quality; the style of each artist adds another dimension to the work.

In the tradition of its predecessors, this work has already established itself as a classic reference in ornithology and biology. It is undoubtedly the most complete and authoritative reference of its kind in the English language. The editors, the authors, the artists, the photographers, and the publisher are to be warmly congratulated for a superb work which will stand as an essential reference for several years. At the price it is offered at, it is a bargain. It is a great pleasure to recommend it highly to all who are seriously interested in birds or who work in ornithology.

HENRI OUELLET

National Museum of Natural Sciences, National Museums of Canada, Ottawa K1A 0M8

Flying Squirrels: Gliders in the Dark

By Nancy Wells-Gosling. 1985. Smithsonian Institution Press, Washington. 128 pp., illus. Cloth U.S. $24.95; paper U.S. $9.95.

All too often, flying squirrels escape detection during small mammal surveys, faunal inventories, and the regular ramblings of naturalists. As a result, the distribution, habits and habitat of these nocturnal squirrels are inadequately documented in Canada. This book will help to change things. Informative, inspirational and easy to read, this first book on North American flying squirrels may expose their seemingly secretive world to curious human eyes across the country.

Nancy Wells-Gosling is a zoologist and freelance writer from Michigan who has written extensively on flying squirrels. She has closely observed the Northern Flying Squirrel, *Glaucomys sabrinus*, and the southern species, *Glaucomys volans*, in the wild, and has successfully raised members of both species as pets. In this book, she combines ten years of personal observations and research with a fairly comprehensive literature review. The result is a layperson's treatise on the natural history of flying squirrels that will please biologists and naturalists seeking an introductory reference on the subject.

The first ten chapters take the reader through a year in the life of flying squirrels. General descriptions of the two species and their ranges are followed by chapters that cover photoperiodicity, reproductive behaviour, development of young, characteristics of nests, food and habitat, limiting factors, locomotion, food storage, and winter activity. Chapter titles such as "Bringing up baby" and "Be it ever so humble" are evidence of her natural, non-academic style. These life history chapters are followed by chapters on field study techniques, flying squirrels as pets, and flying squirrel lore. An extensive bibliography and subject index are included, as are appendices on habitat records for flying squirrels and the evolutionary history of flying squirrels in North America.

The author admits her coverage of Northern Flying Squirrel ecology is much less comprehensive than that of the southern species. In part, this reflects her experience since she has spent more time with Southern Flying Squirrels. It may also indicate that the book is aimed at the eastern U.S. book market, where *G. volans*

is the common, and often the sole, flying squirrel species. It is certainly a reflection of the comparatively small amount of published data available on the more widespread Northern Flying Squirrel. She ably points out where more research is needed on both species, and devotes a chapter — "First, catch your squirrel" — to getting the work started.

There are some slight but noticeable discrepancies between the life-history characteristics she describes in the book and those described in the available literature. Because of the great behavioural lability observed in flying squirrels throughout their range, this is to be expected. She attests to this in her epilogue by mentioning that the pre-publication reviewers, who are also bona fide flying squirrel researchers, almost invariably remarked that squirrels at their study sites behaved differently from the ones she described.

One minor criticism that might be levelled against this book deals with the distribution records of the Southern Flying Squirrel in Canada. Obviously missing on the range map for *G. volans* are records in southern Nova Scotia (T. J. Wood and G. D. Tessier. 1974. *Canadian Field-Naturalist* 88: 83–84). As well, literature records for Southern Flying Squirrel habitat in Canada are not provided in the appendix. Southern Flying Squirrels were collected from a "well-drained mature beech-maple forest" in southwestern Quebec (D. J. Oxley and J. M. Gall. 1977. *Canadian Field-Naturalist* 91: 424). This is the northern-most record for the species in North America, so it may not be indicative of its preferred habitat in Canada. It is, however, the only published Canadian specimen record that included a habitat description.

Seventy-eight black and white photographs satisfactorily depict both species throughout their life histories, although there is a preponderance of pictures of Southern Flying Squirrels, and of squirrels in the home and in the hand. The cover of the paperback edition sports the only colour photographs, and unfortunately the photograph on the back cover is mislabelled. The caption describes the two species side by side on a feeding platform, showing their most important field identification features. On the picture the species are reversed. The caption was used previously in the book for a similar picture, so the fault likely lies with the publisher. The appealing text layout is on high-quality paper and is free of typographical errors.

This book fills a gap in the natural history literature by pulling together records and research of these little-known North American squirrels. The decidedly "southern" slant may make it of most interest to readers living in *G. volans* country, but it is a valuable general reference on both species. The book does not include technical descriptions of musculature, skeletal structure or subspecies characteristics. It is, however, full of highly palatable prose from an inquisitive and informed author. I recommend it to everyone interested in the ecology of flying squirrels, especially if keen on personally observing these interesting animals.

MARK STABB

Faculty of Forestry, University of Toronto, 203 College Street, Toronto, Ontario M5S 1A1. Home address: 504 Clinton Street, Toronto, Ontario M6G 2Z4.

Wings Along the Winnipeg: The Birds of the Pinawa – Lac du Bonnet Region, Manitoba

By Peter Taylor. 1983. Reprinted with supplement and minor corrections 1985. Eco Series No. 2. Manitoba Naturalists Society, Winnipeg. 223 pp., illus. $10.

This second contribution to the "Eco" series of the Manitoba Naturalists Society is the largest and most comprehensive regional ornithological work in Manitoba to date. Taylor, a relative newcomer to the province, has succeeded very well in achieving his three objectives of providing a reference for local naturalists, a detailed guide for visitors, and a detailed data base for future reference, all in an easy-flowing text.

The text begins with a brief description of the study area to the northeast of Winnipeg on the edge of the Precambrian shield, followed by a capsule history of bird observation in the area. I heartily endorse Taylor's call for information on the fate of the valuable notes of Victor B. Latta, Manitoba's nest-finder extraordinaire. A 12-page bird-finding guide to local "hot spots" will interest naturalists in general, as such non-bird specialties as the Mink Frog are also included. Five pages are devoted to definitions, abbreviations, and other terms, where we learn that the timing of the publication of the first issue coincided too closely with release of the sixth edition of the American Ornithologists' Union check-list to enable Taylor to use current names and taxonomic sequence. He thus relied on the American Birding Association's list, with only a few of the old (fifth edition) names remaining, but retaining the old sequence and grouping of families. The only name which differs substantially from that in current use is Louisiana Heron instead of Tricolored

Heron in the 1985 supplement. The bulk of the book consists of species accounts, ranging in length from a paragraph to about 1½ pages, often illustrated with a photograph or drawing. A 2½ page list of literature cited seems skimpy at first glance, but most journal articles are cited in the text in an abbreviated form. Appendices summarize breeding evidence, chart Christmas bird counts, and update significant observations to early March 1985. A species index concludes the book.

The species accounts primarily cover status and periods of occurrence in the area, with nesting and other local life history information frequently included. As with many of the best regional works, there are numerous tid-bits of interest to a much wider audience. Many of these perhaps deserve a separate note elsewhere, but others will help provide fodder for review papers by other authors. There are several accounts of species interactions, descriptions of atypical plumages and hybrids, notes on responses to caterpillar outbreaks, banding recoveries of Evening Grosbeaks, and such vignettes of history as the use of Rock Doves in the 1930s as messengers for fire fighters. Especially amusing are accounts of Bald Eagles stealing fish from an otter, a Pileated Woodpecker "shoveling" snow to get at a particular limb and a grackle carrying three small fish in its bill puffin-style. Latta's observations of Ruffed Grouse nests usually being close to drumming logs of males contrast with the finding of F. C. Zwickel and his associates that Blue Grouse nests on Vancouver Island are nearly always in areas outside male territories. Taylor's observations of two American White Pelicans robbing food from Double-crested Cormorants are of special interest in light of recent observations of extensive kleptoparasitism by these pelicans on cormorants in Nevada, to date published only in abstract form (J. G. T. Anderson. 1985. Colonial Waterbird Group Newsletter 9(3):17). Many other interesting behavioural notes are interspersed throughout the book.

This book is both well written and thoroughly proof-read. I found only four proof-reading lapses, the citation of Ernest Thompson Seton's 1891 treatise on the birds of Manitoba as Seton on p. 82 instead of Thompson being the only one of significance. Taylor has researched his subject thoroughly, delving into records of the Prairie Nest Records Scheme, a local breeding-bird survey route, and unpublished notes of several observers in addition to the literature. The only omissions of local importance are Christmas Bird Counts from Seven Sisters Falls within his study area in 1962, 1963, 1965 and 1966, and perhaps the 1962 and 1963 counts at Pointe du Bois, just outside his boundaries. These counts would add a few records of infrequently wintering species, although the date of a Northern Cardinal record on one of them is included in the text. Taylor's list of local host species of the Brown-headed Cowbird includes two species (Yellow-rumped Warbler and American Redstart) for which no records are mentioned under the host species and misses Swainson's Thrush for which a host record is mentioned. Houston's review of Passenger Pigeon records on the prairies (*Blue Jay* 30: 77–83, 221–222, 1972) would have added useful perspective to both the Passenger Pigeon and the Mourning Dove accounts, and the review of hybrid bluebirds by Rounds and Munro (*Wilson Bulletin* 94: 219–223, 1982) would have also added perspective to a possible local record. B. W. Cartwright authored the "Wild Wings" column in the now defunct *Winnipeg Tribune* before Angus Shortt assumed this role. Although the Eastern Meadowlark record is the first with good confirmation in Manitoba, Harold and David Mossop had an earlier record near Woodlands in 1960 (H. Mossop. 1963. *Chickadee Notes* No. 431), and David Braddell described a third possible record of the White-winged race of Dark-eyed Junco in Manitoba at Reston (Natural History Society of Manitoba Newsletter 26: 8–9, 1971).

These minor comments do not detract from the high quality of this comprehensive regional work of which both the author and the Manitoba Naturalists Society can be proud.

MARTIN K. MCNICHOLL

Long Point Bird Observatory, P.O. Box 160, Port Rowan, Ontario N0E 1M0

Wolves in Canada and Alaska

Edited by Ludwig N. Carbyn. 1983. Proceedings of the Wolf Symposium held in Edmonton, Alberta, 12-14 May, 1981. Report Series Number 45. Canadian Wildlife Service, Ottawa. 135 pp., illus. $12.50 in Canada; $15 elsewhere.

Despite wide-scale, conflicting public concerns over the value of Wolves to our society, there has been little non-technical literature available that is an unbiased expression of up-to-date scientific knowledge on the status and biology of Wolves, their interaction with prey, and current management techniques and policies. There are many reasons for this: the complex nature of predator-prey interactions, the emotional atmosphere

that pervades attitudes to and decision-making about Wolves, and the ethics of our treatment of that species as we seek management solutions.

In 1981 The Canadian Wildlife Service (CWS) sponsored a symposium to bring together many of the leading research scientists and managers from Canada and Alaska. The stated purpose of the symposium and these proceedings was to "... document the status of wolves in Canada and to discuss some of the problems related to their conservation." This book was designed to be of use for both laypersons and scientists, and represents a view of Wolves as a species which can and should be managed.

The editor has provided an excellent introduction summarizing the history of human-Wolf conflicts and the main points of each paper, as well as indicating which papers are intended for scientific versus non-professional audiences. The first major section begins with a paper on the taxonomy of Wolves in North America, and is primarily intended for a technical audience. It is an important summary of the developmental history and the fluctuating distribution pattern of Wolves in North America. For those familiar with the author's (Nowak) 1974 monograph on this subject, the paper integrates more recent information in a rigorous and cautious analysis.

In the remainder of the "Status" section, readers will quickly note that the quality and quantity of information on Wolf numbers, distribution, harvest levels, and control activities vary among jurisdictions and not all papers deal with each of these subjects. The paper on Alaska Wolf management, for example, details mainly the history of Wolf control programs. The remaining papers constitute more straightforward status reports, and those from Manitoba, Ontario and Quebec stress the importance of Wolves as an integral component of the environment. While status reports quickly become obsolete due to changing conditions (for example the recent major Wolf control programs in B.C. and Yukon) these papers nonetheless achieve the editor's objective of serving ". . . as benchmarks against which changes in the distribution of the species (wolves) can be evaluated in the future." Readers will find all of these status reports clearly written and free of confusing jargon.

The second major section of the proceedings contains eleven papers on the biology and management of Wolves. At least four of the papers in this section are intended for a scientifically-trained audience. While theoreticians may dispute some of the bases for conclusions in the lead-off paper on population dynamics of Wolves, the implication that ungulates limit Wolves (due to their importance as food for Wolves) is an intriguing and important one for managers. This theme of the importance of food for Wolves is carried on into the next paper on Wolf reproduction. The two senior authors (Packard and Mech) had argued in a 1980 paper for the importance of social behaviour as a regulator of reproduction. This argument is now re-appraised in favor of food.

Alternate views are presented in two papers on the necessity of strategies to maintain genetic variability among Wolf populations, whose distributions may become more patchy over time due to human impact. This is not a question that will be easily resolved and both authors are generally cautious in interpreting the implications of genetic variability for Wolf management. Educators and naturalists will find the paper on a well-known interpretive program that allows visitors in Algonquin Park, Ontario to hear Wolves howling in the wild a fascinating merger of recreation and wildlife management.

Two papers deal with Wolf-ungulate interactions from quite different perspectives: the impact of controlling Wolf numbers on an Alaskan Wolf population and the effects of Wolves on Caribou mortality in the Northwest Territories. The first of these papers presents information on the losses Wolf populations could sustain and yet still be maintained. The importance of this type of information for Wolf management and the crucial necessity for more data are demonstrated by the results of the paper on Wolf-related Caribou mortality. The author (Miller) argues that Wolves limit the population growth of the Kaminuriak herd of Caribou, and to effectively manage for Caribou, Wolf numbers must be reduced.

Three papers deal with so-called 'problem' Wolf management. The first article is a brief but excellent review of livestock depredation by Wolves across western Canada, while the second paper summarizes a specific research study in Alberta on cattle predation by Wolves. The third paper gives an evaluation of 'problem' Wolf management programs in British Columbia and promotes site-specific reactive measures. This article would have made interesting historical reading if the author's (Tompa) views on Wolf-ungulate programs had been included, given the furore that resulted from the subsequent northeastern B.C. Wolf control program. A final techniques paper on discriminating between Wolf and dog tracks concludes the symposium proceedings.

These proceedings are essential reading for those involved in Wolf-ungulate or Wolf-livestock interactions, as well as those involved in other areas of predator-prey ecology. In his introduction, the editor correctly states that laypersons will likely find the sections on the status of Wolves, Wolf-livestock interactions, and park interpretation of most immediate interest. The decision to have all papers reviewed by two or more scientists prior to publication

has resulted in a publication of consistent quality. All papers begin with an abstract which provides a "quick review" of their contents. Illustrations and tables are well-labelled and presented, and are consistent in type and style throughout the book, a major editorial achievement. The lack of an index, in common with Canadian Wildlife Service publications, is nonetheless a deficiency.

Ethical considerations in Wolf control was a topic raised in panel discussions at the Edmonton symposium and it is unfortunate that the transcripts of those discussions were not included in these proceedings. They would have provided a necessary balance to the weight of scientific solutions evident in some of the articles. Management is, after, all a framework for human values, some of which are not necessarily represented by scientific solutions.

DAVID A. GAUTHIER

Department of Geography, University of Regina, Regina, Saskatchewan S4S 0A2

BOTANY

Guide to the Literature for Identification of North American Lichens

By Irwin M. Brodo. 1985. Syllogeus 56. National Museum of Natural Sciences, Ottawa. 39 pp. Free.

Irwin M. Brodo's *Guide to Literature for the Identification of North American Lichens* may not be what one would consider stimulating reading but it is an invaluable tool for anyone seriously interested in the study of lichens. Almost every lichenologist maintains a list of the most useful books and articles for any given area or groups of species. Syllogeus 56 is Irwin Brodo's update of an excellent list of lichen references prepared by Dr. Henry Imshaug for his students. Dr. Brodo's *Guide* will be a sound basis for any study of lichen identification, to which lichenologists may add new references as they appear in the literature or become important in their studies.

The *Guide to the Literature for the Identification of North American Lichens* is divided into four major parts.

Part I deals with general references, and lists works not only from North America but also some from Scandinavia, England, and Germany. The European references are included because they contain keys to macrolichens which also occur in North America.

Part II contains selected references dealing with groups of species or geographic regions. Within this section, there are several categories of references, including keys to genera or families, species of macrolichens, species of crustose lichens, lichen parasites, arctic species, boreal and hemiarctic species, central North American, northeastern United States and Canadian, southeastern United States, western North American, and Maritime lichens. Dr. Brodo notes that under each of those sections, the articles and books are listed in their approximate order of usefulness. As he points out, this subjective ranking has advantages and disadvantages, since for ". . . certain regions another order may be more appropriate . . .". In future editions of this guide perhaps alphabetical order might be more appropriate. He has wisely included several works considered out of date, but very valuable in delimiting the taxa according to older literature and as nomenclature references.

Part III contains references to various generic revisions or monographs. Also included are a few floristic treatments. The list contains only published articles and some doctoral theses available from the University Microfilms in Ann Arbor, Michigan. Very few M.Sc. and Ph.D. theses done by students in Canada have been included; Eileen Matthew's thesis on Ramalina is not presented, nor is C. D. Bird's *Key to the Tree-Dwelling Lichens of Alberta: Prairies and Parkland* published by the Alberta Department of Education, 1976. Further, Dr. Brodo has not included unpublished manuscript keys even though many of them are circulating rather widely among working lichenologists. While such keys are not readily available, some of them represent the only comprehensive collection of keys to lichens of various regions. Dr. C. D. Bird's *Keys to the Lichen of the Prairie Provinces* is a good example. Such collections of keys, whether published or unpublished, should have been referenced to at least give the interested student an idea of where he might start looking or to bring to his or her attention the fact that keys already exist for the region. The references in Part III, generic revisions or monographs, seem to be quite a complete list. There are a few references that I think should have been included, for example, Leif Tibel's paper *A Reappraisal of the Taxonomy of Caliciales* published in *Beiheft 79 Zur Nova Hedwigia*, 1984.

One puzzling feature of Part III is the inclusion of genera for which no bibliographic references are given. The reader is left to assume that these genera were never described adequately or that there is no good article

dealing with them in North America.

Part IV is the complete bibliography, citing author(s), year of publication, title, publisher or journal, and pages. Rather than giving cryptic abbreviations for journal name, which could be confusing to new students, Brodo has wisely spelled out the names omitting only "The" and other "little" words.

One reference mysteriously omitted from the *Guide* is Hale and Culberson's *A fourth checklist of the lichens of the continental United States and Canada* published in *The Bryologist* in 1970. While this checklist is no doubt out of date, it is certainly more current than Fink's book of 1935, Magnusson's book of 1952, or Smith's books of 1918 and 1926.

This publication is a 'must' for any serious student of lichenology.

J. W. CASE

CASE Biomanagement, 1865-500 Fourth Avenue S.W., Calgary, Alberta T2P 2V6

Introduction to Bryology

By Wilfred B. Schofield. 1985. Macmillan, New York. xvi + 431 pp., illus. U.S. $45.

At last there is an introductory book on bryophytes that can be used as an alternative to N. S. Parihar's *Bryophyta*. Schofield's beautifully illustrated new book is a masterful piece of work which could only be written by someone with his particular knowledge, experience, and love of the plants. I think both teachers and students will find it a delight to use in introductory bryology courses because of its clarity and simplicity in presenting the subject matter.

Introduction to Bryology originated from notes used by the author, himself a teacher, for lectures given over a span of more than 20 years at the University of British Columbia. It includes 25 chapters, a glossary, and 10 appendices.

The first chapter is a short introduction to the bryophytes as a whole, primarily covering their morphological similarities and life cycle. The next nine chapters are devoted to the mosses, with one covering the class Musci, and one covering each of the seven subclasses recognized by the author, namely Andreaeidae, Sphagnidae, Tetraphidae, Polytrichidae, Buxbaumiidae, Bryidae, and Archidiidae. In each of these, the morphology of the gametophyte and sporophyte of the mosses in the respective subclass is explained, followed by a discussion of evolution and relationships. The ninth chapter on the mosses discusses evolutionary trends and interrelationships among the mosses. It includes charts comparing the gametophytic and sporophytic features of the seven subclasses.

The liverworts are discussed in the eight following chapters. Again, one chapter is devoted to the class Hepaticae, followed by chapters covering the six orders that the author recognizes: the Calobryales, Jungermanniales, Metzgeriales, Sphaerocarpales, Monocleales, and Marchantiales. The same type of information as was given for the mosses is presented for the liverworts. Also, as in the mosses, one chapter is used to summarize the evolutionary trends and interrelationships among the liverworts, with charts comparing the gametophytic and sporophytic features of the six orders.

The hornworts, class Anthocerotae, are covered in the same manner as the mosses and liverworts. However, the single chapter is short when taking into consideration the amount of interest shown in, and the number of publications that have appeared on, this fascinating group of plants.

The remainaing six chapters deal with general bryological topics: history of bryology, cytology and genetics, chemistry, physiology, ecology, and geography. A short glossary contains the necessary terms that the layperson requires for quick reference. The book finishes with ten useful appendices that deal with collecting bryophytes and processing for study, a comparison of bryophyte classes, stains for revealing pores in Sphagnum, freehand sectioning bryophyte material for anatomical study, mounting medium for permanent slides, some simple methods for culturing bryophytes, squash techniques for cytological study of chromosomes of mosses, collecting material for study of major evolutionary lines of bryophytes, keys for determining subclasses and orders of bryophytes, and manuals for determination of bryophytes. Another relevant appendix could have been added here. With the increased use of the scanning electron microscope in bryological studies, information on the techniques used to prepare material for this kind of study would be of value.

One of the best features of the book is the excellent quality of line drawings that are so abundant throughout the text, illustrating the structure and habit of the bryophytes. Several artists contributed drawings, among them Wilf Schofield himself, and Muriel Schofield, one of his three daughters. The illustrations by Patricia Drukker-Brammal, who also did the drawings for *Some Common Mosses of British*

Columbia, are particularly exquisite.

The book also has many other good features to recommend it. Among them, the long chapter on geography is especially outstanding, a result of the long-time research interest by the author in this field. The chapter on the history of bryology is unique and it gives the reader a quick perspective on some of the more prominent bryologists of the past. In addition, there are several scanning electron micrographs of spores, rhizoids, peristome teeth, and other morphological features. Finally, each chapter concludes with a list of many references to further reading matter on its respective subject.

The author and Macmillan Publishing Company are to be commended for producing such a scholarly and easily readable book which should become the standard text for schools in many parts of the world. I highly recommend it to anyone with the desire to learn more about bryophytes.

ROBERT R. IRELAND

National Museum of Natural Sciences, National Museums of Canada, Ottawa, Ontario K1A 0M8

The Arctic and the Rockies as seen by a Botanist Pictorial

By In-Cho Chung. 1985. In-Cho Chung, 1251 Towncrest Rd., Williamsport, Pennsylvania. 17701 343 pp. illus, U.S. $35.00 + $2.50 postage.

Few of us will have an opportunity to see the wild flowers of the Rocky Mountains and far fewer the grandeur of the Arctic and its wild flowers. In-Cho Chung has travelled widely across the Canadian North, Alaska, and through the Rocky Mountain chain. With his camera he has brought back a pictorial record of the flora and some of the impressive terrain.

This book contains a collection of almost 600 excellent colour photographs of arctic and alpine habitats and the flowers that are found in this most fascinating country. Each picture is accompanied by a paragraph which includes the common and scientific names, location, date, and often comments on ecology, distribution, associated species, and some descriptive information. The pictures are arranged, in general, in a sequence from east to west across the north and southwards through the Rocky Mountain chain into the United States as far south as Colorado. Introductory pages include information on the area covered — its topography, geology, climate, permafrost, and vegetation. Selected references and an index to common and scientific names and geographic localities complete the book. My copy came with two separate pages of errata.

In-Cho Chung has created a book that would be a welcome gift to anyone who has travelled in the north or the Rocky Mountains, or indeed has a yen to do so. It would also be a useful companion to such technical floras as Porsild's *Illustrated Flora of the Canadian Arctic Archipelago*, Porsild and Cody's *Vascular Plants of Continental Northwest Territories*, and Hultén's *Flora of Alaska and Neighboring Territories*, which with the exception of a few colour pictures in the latter, contain only line drawings.

WILLIAM J. CODY

Biosystematics Research Centre, Agriculture Canada, Ottawa, Ontario K1A 0C6

The Rare Vascular Plants of British Columbia

By Gerald B. Straley, Roy L. Taylor, and George W. Douglas. 1985. National Museums of Canada, Ottawa. Syllogeus 59. 165 pp. Free.

Since the late 1970s, the National Museum of Natural Sciences has been publishing a marvellous series of reports on the rare vascular plants of the Canadian provinces and territories. Under the auspices of the museum's Rare and Endangered Plants of Canada Project, ten such reports have been published (although reference to the Northwest Territories and Yukon Territory lists [Syllogeus 23 and 28, respectively] are inexplicably omitted from the list of titles on the inside front cover of the present list).

The British Columbia list maintains the excellent style and format of the series. It commences with an Introduction that discusses the general nature of the landscape and its diverse flora (over 2500 species), and lists the 14 endemic taxa known from the province. After defining the degrees of rarity utilized in the text, the authors describe their particular methodologies and

assumptions in conducting the study. It is here that a significant departure is made from the approach followed in previous studies in the series.

This report evaluates rare taxa within four categories, ranging (in descending order) from R1 (a few populations consisting of a few individuals each) to R4 (taxa of restricted range but with large populations). This is a much broader concept of 'rare' than is followed in the other Rare Plants of Canada reports and results in a very large list of taxa — almost 820. Only R1 and R2 taxa fit easily within the defined limits of previous reports. If one were to consider only these, the list is significantly (and more realistically ?) reduced to 493 taxa. The authors seem to have sensed something of the difference themselves, since they chose to provide provincial distribution maps only for R1 and R2 taxa.

A useful discussion of the implications for natural resources management and conservation as a result of the designation of rare plant species follows. A short but effective treatment of the pattern of distribution of rare taxa completes the introductory section. A French language translation of the Introduction is included here; the rest of the text is bilingual. The Introduction appears to be quite free of error. The only apparent error I noted was the inclusion of a rejected species (*Lewisia rediviva*) in the list of typical rare taxa from the dry interior of the province.

The species treatments are presented in the standard Rare Plants of Canada Project format, viz., scientific name, habitat, herbaria consulted, map references, range in British Columbia and beyond, and rare status in British Columbia and beyond. An indication of the appropriate biogeoclimatic zone is a useful addition to the habitat descriptions. Although these treatments proceed well, for the most part, spelling errors in two consecutive species (*Juncus articus* [sic] and *Jucus* [sic] *biglumis*) do not increase confidence in the proofing of the final text.

A serious problem in the species treatments, however, is the mannner in which synonyms are handled. Although synonyms are said to be included if such names are found regularly in major publications, there are so few listed (less than 75 by my count) that one wonders how carefully this was done. Surely such genera as *Potentilla, Salix, Polystichum*, and *Carex* require more than a cumulative total of four synonyms?! To complicate matters further, the synonyms that are employed are not listed with the species in question, but are placed alphabetically within the overall list and can easily be overlooked. As these rare taxa are almost by definition poorly known, it is especially important that the nomenclature be clear. The sparse and cumbersome use of synonymy in this study does not assist in that aim. Fortunately, no other important problems were noted in the otherwise well-documented species lists, which are presented by genus in alphabetical order.

Following the species treatments and a list of literature cited, a thorough Excluded Species appendix is offered. This is important and useful information, spelling out as it does those species which were considered rare initially in this study and/or elsewhere but which have been found not to be so upon further study. In previous studies in the Rare and Endangered Plants of Canada Project, excluded species are listed in the same order as the main text, with indications of the reasons for their rejection being noted after the name, by use of a symbol or acronym. The British Columbia list, however, chooses to list such taxa under headings indicating their rejection criteria. This can require that the reader check up to five separate lists in search of a possibly excluded species — an unnecessarily involved and time-consuming process.

Appendix II lists all the taxa considered rare in British Columbia (alphabetically by family) in checklist form. The report is concluded by excellent maps illustrating the provincial distribution of the almost 500 R1 and R2 taxa.

The British Columbia rare plant study is a welcome and important addition to the Rare and Endangered Plants of Canada Project. Had the synonymy problem been avoided and a more restrictive concept of rarity been adopted, it would perhaps have been even easier and more practical to use. It contains, nevertheless, a wealth of vital floristic data and is an important contribution to our knowledge of the rare Canadian flora. With the slashing of budgets and manpower reaching such severe proportions at the National Museums of Canada, it is also a real tribute to that institution that they are able to distribute such important and well-packaged information at no charge.

DANIEL F. BRUNTON

2704 Marie Street, Ottawa, Ontario K2B 7E4

Grassland Studies

By Juliet Brodie. 1985. Practical Ecology Series. Allen & Unwin, Winchester, Massachusetts. x + 100 pp., illus. U.S. $9.95.

Grassland is a term that implies very different habitats to different people. Most Canadian biologists would think of the western prairies, or other vast, natural, grass dominated ecosystems of the world: African veldts, Asian steppes, and South American pampas. As such, the title of this volume might be somewhat misleading. Written for the United Kingdom audience, the book attempts to provide, for sixth form (senior high school) students, an ecological study program using the most readily available habitat in that country — open, grass dominated areas. Examples of grasslands given in the preface and introduction include playing fields, lawns, road verges, pasture (of various types), and parks. Certainly such grasslands are located in the neighbourhood of all Canadian high schools.

In 26 "independent" exercises, the author attempts to introduce the teenage student to a range of general ecological parameters through data collection and analysis of simply constructed experiments. Each exercise consists of an introduction with background information, a stated aim(s), a list of required materials, a step-wise procedure, and a series of questions.

Introductory remarks tend to be brief and rather simplistic, even for the intended young audience. This can be easily rectified with supplemental readings or lectures. Materials required are kept to a minimum and, for the most part, are easily acquired or built. Some materials may be difficult for the private individual to acquire (e.g. ethyl acetate and Longworth mammal traps). For even a small-budgeted educational institution the materials required are inexpensive, especially since most can be reused for many years of study. Methods are clearly stated, easy to follow, and often accompanied by example results and data display. The questions that end each exercise are designed to provoke thought on causal factors for observed results, deficiencies and improvement of experimental design and sampling technique, and synthesis with parameters observed in other exercises.

The fact that the book is written for a British audience means the identification guides and keys to vascular plants are useful only in that geographic region, although faunal guides are general enough to be useful almost everywhere. Amended or supplemented vascular plant identification guides are required for the Canadian context. The manual provides an excellent program for investigating the basic factors affecting ecological systems and, to a certain extent, their interactions. Students following the exercises will gain practical experience in the collection of a wide range of biotic and abiotic ecological data, as well as some basic data manipulation and display techniques. With the addition of supplemental reference material tailored to Canadian habitats, the book provides a solid introduction to ecology for the often neglected, serious young student.

S. J. DARBYSHIRE

Biosystematics Research Centre, Wm. Saunders Building, Central Experimental Farm, Ottawa, Ontario, K1A 0C6

ENVIRONMENT

Climatic Change in Canada. 4. Annotated Bibliography of Quaternary Climatic Change in Canada and 5. Critical Periods in the Quaternary Climatic History of Northern North America

Edited by C. R. Harington and G. Rice; Compiled by A. B. Smithers, L. Ghanimé, and C. R. Harington. 1984. Syllogeus 51. 368 pp. and Edited by C. R. Harington. 1985. Syllogeus 55. 481 pp. National Museum of Natural Sciences, Ottawa. Free.

Mark Twain quipped, "everyone talks about the weather but nobody does anything about it." The National Museums series 'Climatic Change in Canada' edited by C. R. Harington certainly brings 'talking about the weather' to a high level of sophistication. Since the weather discussed is generally at least a few centuries old, the contributors can be excused for not trying to change it. These two volumes are the most recent of the series which was begun in 1980, and continued in 1981 and 1983 (Syllogeus Nos. 26, 33, and 49).

The importance of climate to agriculture, forestry and other renewable-resource-based industries warrants for this series a far greater readership than it will likely get, considering the low-key approach the National Museums takes to advertising its publications. The series, which brings together articles in a diverse collection of related disciplines, is based on the belief that "a knowledge of past climate, if carefully

accumulated and interpreted can lead to a better understanding of the nature, timing and strength of future climatic alteration."

Volume 4, the bibliography, presents titles and abstracts for 912 published articles dealing with various aspects of Quaternary and Holocene climate in Canada. Criteria for inclusion appear to have been availability in indexes of several Montreal area libraries, a review of five North American journals which reguarly cover the subject, and the reprint files of the editors. It would not take long to find papers that are not included but the objectives of the volume are generally well met. These were to refresh involved professionals, to act as an introduction to the literature, and to illustrate the diversity of involved disciplines and the recent explosion of publications. The entries are organized alphabetically and chronologically by author and date. The annotations consist either of the author's own abstract or summary or of an abstract prepared by the compilers. The entries are usefully indexed by province or territory, and subdivided therein by topic or discipline.

Volume 5 begins with a cartoon transaction over the miserablest of mink pelts at a snowbound Hudson's Bay Company post. On the wall the calendar ominously reads, "August 1816". This volume, the result of a symposium on critical periods in Quaternary climatic history, documents such events as the Hypsithermal (the post glacial warm period of ca. 4000 years ago), the 'Little Ice Age' of 1814–1821, the dustbowl drought of the 1930s, and the climatic effects of volcanic eruptions.

The opening lecture by M. K. Thomas does much to place the science of paleoclimatology in perspective and to impress upon the reader the importance of this discipline to society as a whole.

The twenty-five papers and abstracts are arranged by subject or subdiscipline. Two papers, one by M. Andrews, the other by C. R. Harington, discuss the importance of bibliographies in coping with the virtual explosion of information in this field which has occurred in the last thirty years.

Two papers are based on data from the existing Atmospheric Environment Service (A.E.S.) weather network. Berry and Williams's paper on the 1930s drought on the prairies is sobering with its estimation of the frequency with which such droughts can be expected to occur. W. R. Skinner's article on the effects of volcanic dust veils on Canada's climate demonstrates a weak temperature depression and an interesting decrease in precipitation.

Six papers reconstruct past climate from historical records. Moira Dunbar's examination of the ice cover of arctic waters from 19th century sailing records and from aerial reconnaissance in the 1950s and 1960s shows pronounced differences in the ice on these waters between the two centuries. A. J. W. Catchpole finds evidence from Hudson Bay Company (H.B.C.) logbooks of depressed temperatures and an eastward shift of the Arctic Front during the summers of 1816–1817. C. Wilson's two papers also examine H.B.C. records and demonstrate extremely low summer temperatures for the summer of 1816 and construct synoptic daily weather maps for that year. T. Ball uses H.B.C. records of thunderstorms, rainfall, and frequency of wind direction to illustrate a shift of the Arctic Front over northern Manitoba in the 1760s. Analysing diaries and early instrumental records, W. R. Barron and G. Gordon reconstruct the weather of New England over the last three centuries, and find evidence for a warming trend that occurred from the early 1800s until about 1940.

The role of archeology in detecting minor shifts of climate in post-glacial time is dangled in front of the reader in a brief abstract by J. V. Wright.

Two papers deal with the results of tree-ring studies. The effects of the volcanoes Tamboura (1815) and Krakatau (1883) were examined by M. L. Parker in trees from British Columbia to James Bay. The most affected trees were at the treeline. An abstract by Jacoby, Ulan, and Cook reports on the use of tree-ring data to determine the length and warmth of growing seasons in Alaska and northwestern Canada from 1574 to the present.

Seven papers are based on pollen analysis of sediment cores. J. B. Macpherson compares present and fossil pollen spectra and suggests the migration of storm tracks through the Hypsithermal of Newfoundland and Labrador. R. J. Mott, tracing the development of vegetation through the late glacial epoch in the Maritime provinces, finds a post-glacial warming trend between 12 000 and 11 000 yr B.P., which may be related to climatic fluctuations long known from the same period in Europe. Bartlein and Webb map modern pollen frequencies and summer isotherms in Eastern North America and, with multiple regression and fossil pollen spectra from 6000 years ago, create an isotherm map for that time. L. V. Hills and coauthors present three papers dealing with the pollen record from southern Alberta and southeastern British Columbia. Sediment cores from Waterton Lakes National Park, from Elk Valley, B.C. and from Crowsnest Pass add to the knowledge of post-glacial climatic change in the region and distinguish climatic change from vegetational succession. Limits of the Altithermal warm period (7000 to 5000 yr B.P.) are discussed in the third paper. R. Mathewes' paper reviews palynological studies in southwestern British Columbia and examines the Holocene coastal-interior ecotone and the post-glacial warm dry period of 10 500

years ago.

J. T. Andrews' paper on holocene environments on Baffin Island summarizes previous work and presents a series of maps which show the extent of glacial and marine ice and summer temperatures derived from pollen studies from 10 000 years B.P. to the present. Matthews and Schweger document the distribution of "Old Crow" tephra, a volcanic ash which is useful for dating sequences from the height of the Wisconsinan in the Beringian refugium.

Two final papers on paleoclimatology and glaciology deal with a little ice age in the 16th century and with the causes of the big ice age. Using oxygen isotope dating and melt characteristics in ice cores taken from ice caps throughout the Canadian High Arctic, B. Alt demonstrates the occurrence of a cold wet period in the Arctic in the late 1500s, and shows the shift of atmospheric circulation required to achieve those conditions. C. U. Hammer's abstract on the causes of the Wisconsinan glaciation suggests volcanism as a possible triggering mechanism for glaciations.

Climatic Change In Canada provides insights on a subject which has far-reaching implications for Canadian life. Researchers involved in paleoclimatology will already be aware of this worthwhile series, but the series will also be of interest to a larger audience in many other disciplines.

JAMES BRIDGLAND

Resource Conservation, Cape Breton Highlands National Park, Ingonish Beach, Nova Scotia B0C 1L0

The Status of Ecological Reserves in Canada

By P. M. Taschereau. 1985. The Canadian Council on Ecological Areas and The Institute for Resource and Environmental Studies, Dalhousie University (available form CCEA Ottawa, Canada K1A 0E7). 120 pp. $8.00.

Pierre Taschereau has undertaken the job of documenting the state of the art of Ecological Reserves in Canada. The author's purpose was "to summarize what has happened with respect to Ecological Reserves in Canada since the conclusion of IBP in 1974". He has utilized literature research with extensive personal contacts across the country. The findings are summarized for several federal government departments, each province, both territories, and some private organizations.

This work is the first of its kind for Canada, and it is long overdue. It is reasonably comprehensive, is up to date until early 1985, and appears to be accurate in its reporting. It was of sufficient value that I am now using it as a text in a university course on the ecological components of parks planning and management.

In the sections outlining each program, Taschereau attempts to take a neutral approach to the topic. He reports but does not extrapolate or unreasonably expound. He rigourously references his facts. But his opinions are more clearly visible in the final chapter of discussion.

The author uses the following definition of ecological reserve: "a legally protected area where human influence is kept to a minimum". But this definition is used very loosely. For example both Biosphere Reserves and National Wildlife Areas are discussed even though very active landscape alteration and management occur on sites within these programs. In addition, the International Biological Program (IBP) list of sites is discussed even though many of these sites are on private land and are not legally protected at all. Conversely, in a discussion chapter a chart of Ecological Reserves is provided that contains only those areas that are titled Ecological Reserves in law. Areas that are called something else, such as those of the nature reserve class of Ontario Provincial Parks, are excluded.

National Parks are discussed in the book, but a majority of Provincial Park programs are not. It seems to be an unfortunate omission that the excellent provincial park programs in provinces such as British Columbia, Ontario, and Quebec are not included in the analysis. It can be argued that many provincial parks provide adequate protection to extensive amounts of natural area.

This waffling between the use of a strict definition of Ecological Reserves and the use of a broader concept incorporating natural or semi-natural areas can be seen as a reflection of the diversity of institutional arrangements extant in Canada. And underlying all of it is a variety of personal attitudes and approaches amongst the people in the field. Taschereau reflects this diversity. However, the reader is left with the feeling that any reserve or area not called an Ecological Reserve under Ecological Reserve Act legislation is somewhat less than desirable.

The book is a reasonable summary of the large number of park, protected area, and ecological reserve programs that occur across Canada. Unfortunately the book's title and the definition of Ecological Reserve give too narrow a view of the book's contents. In some ways, the book's contents give too narrow a view of the status of protected area programs in Canada.

The book clearly reveals a positive story. Ecological Reserve establishment and management is very much alive and well in Canada. There is a wide discrepancy in the success of various programs in such aspects as governing legislation, staff competency, efficiency and power of the bureaucracy, public support, and field management.

Recent new initiatives are occurring in National Parks, in the definition of Environmentally Significant Areas in the northern territories, and in nature reserve establishment in Ontario. All of the Atlantic provinces lag behind. Quebec shows recent signs of starting to move forward more quickly. In total, one gets the feeling of a broad advancing front of activity with some programs out ahead and some behind, but with all moving forward.

Any person interested in the planning and management of ecological areas in Canada should read this book. It is technical and slow reading but it is the compendium that some of us have been waiting for, for some time.

PAUL F. J. EAGLES

Department of Recreation and Leisure Studies, University of Waterloo, Waterloo, Ontario N2L 3G1

Natural Heritage of Manitoba, Legacy of the Ice Age

Edited by James T. Teller. 1984. Manitoba Museum of Man and Nature, and *Manitoba Nature Magazine*, Winnipeg, Manitoba. 208 pages. Illus.

This book presents to a general audience the evolution of Manitoba's landscape. The nine chapters, which are expanded versions of articles previously published in *Manitoba Nature Magazine*, are written in non-technical language by specialists from the University of Manitoba and various provincial government departments.

An introductory chapter on pre-Quaternary geology describes the origins of the Precambrian Shield and of Paleozoic sedimentary rocks. It gives an overview of the preglacial landscape. Crustal depression, periglacial features, and glacial landforms are the subjects of the second chapter on the ice age itself, and some of these are expanded upon in the following chapter on Quaternary landforms. The chapter on soils is one of the best in the book and is one of the better general treatments of the subject that this reviewer has seen. It covers soil formation, composition, and classification and is very well illustrated.

The chapter on vegetation begins with an account of how pollen analysis is used to reconstruct vegetation history, and traces the development of Manitoba's vegetation to its present distribution. Floristic elements are listed, and each of the principal biomes of the province is described. The chapter on animals starts with the Paleozoic, then deals with the immigration of the North American fauna from Asia and South America, before describing the faunas of the Pleistocene and the present. The section on Pleistocene animal life describes the fossil record and includes two dioramas of ice-age animal life. The discussion of recent animals is almost wholly restricted to vertebrates, although a few butterflies are mentioned in a section on recent changes in animal distribution.

The chapter on Paleo-Indians of Manitoba describes the archeology and sociology of these cultures in a fashion that does an excellent job of presenting conjecture as apparent fact. The chapter on groundwater describes the water cycle, and the storage capacity and water quality of various aquifers found in the province. The final chapter on the economic mineral heritage of the ice age deals mainly with surficial deposits of economically important aggregates and describes their use in modern society.

The chapters are intended to stand alone as separate entities. There is some overlap between them. The illustrations are generally of good quality, although some of them (e.g. the permafrost map in Chapter 3) relate poorly to the text. The absence of a map showing the location of small towns and highways referred to in the text, especially in the first two chapters, is a definite drawback for the reader who is not familiar with the province. The editing is a bit uneven; some chapters cite sources in the text, while others merely provide a list of suggested reading.

These are minor criticisms. By and large, the book achieves its goal of interesting and informing the general reader of the diverse and fascinating natural heritage of Manitoba. It will be very useful to the province's high school students, for whom it is largely intended. Accompanied by a good road map, the book will add greatly to the enjoyment of tourists visiting the province.

JAMES BRIDGLAND

Resource Conservation, Cape Breton Highlands National Park, Ingonish Beach, Nova Scotia B0C 1L0.

NEW TITLES

Zoology

Alaska's saltwater fishes and other sea life. 1986. By Doyne Kessler and the Kodiak Laboratory, National Marine Fisheries Service. Alaska Northwest, Edmonds, Washington. illus. U.S.$24.95 + U.S.$1 postage.

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Animal intelligence. 1985. Edited by L. Weiskrantz. Proceedings of a meeting, Oxford, June 1984. Clarendon (Oxford University Press, New York). vi + 223 pp., illus. U.S.$39.95.

*__Aphid ecology.__ 1985. By A. F. G. Dixon. Blackie, Glasgow. 168 pp., illus. £17.95.

†**The Atlantic Alcidae: the evolution, distribution, and biology of the auks inhabiting the Atlantic Ocean and adjacent water areas.** 1985. Edited by D. N. Nettleship and T. R. Birkhead. Academic Press, Orlando. xx + 600 pp. Cloth U.S.$40; paper U.S.$19.95.

Bioenergetics of wild herbivores. 1985. Edited by Robert J. Hudson and Robert G. White. CRC Press, Boca Raton, Florida. 328 pp., illus. U.S.$108 in the U.S.A.; U.S.$124 elsewhere.

†**Biological museum methods, volume 1: vertebrates and volume; 2: plants, invertebrates, and techniques.** 1985. By George Hangay and Michael Dingley. Academic Press, Orlando. 400 pp. U.S.$68 and 352 pp. U.S.$58.

*__Bird conservation 2.__ 1986. Edited by Stanley A. Temple. University of Wisconsin Press, Madison. 180 pp. Cloth U.S.$17.50; paper U.S.$12.95.

*__Blackbirds of the Americas.__ 1985. By Gordon H. Orians. University of Washington Press, Seattle. 163 pp., illus. U.S.$24.95.

*__Catesby's birds of colonial America.__ 1985. By Alan Feduccia. University of North Carolina Press, Chapel Hill.

†**City critters: how to live with urban wildlife.** 1986. By David M. Bird. Eden Press, Montreal. 128 pp., illus. $8.95.

Culture of nonsalmonid freshwater fishes. 1986. Edited by Robert R. Stickney. CRC Press, Boca Raton, Florida. 216 pp. U.S.$79 in the U.S.A. ; U.S. $91 elsewhere.

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*__Donald Thompson's mammals and fishes of northern Australia.__ 1985. Edited by Joan M. Dixon and Linda Huxley. Nelson, Melbourne. xi + 210 pp., illus. A$49.95.

†**Ecology and natural history of desert lizards: analysis of the ecological niche and community structure.** 1986. By Eric R. Pianka. Princeton University Press, Princeton. xi + 208 pp., illus. Cloth U.S.$45; paper U.S.$19.95.

Entomology of the California Channel Islands. 1985. Edited by Arnold S. Menke and Douglas R. Miller. From a symposium, San Diego, December, 1981. Santa Barbara Museum of Natural History, Santa Barbara. vi + 178 pp., illus. + maps. U.S.$20.

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Evolutionary ecology of marsupials. 1985. By Anthon K. Lee and Andrew Cockburn. Cambridge University Press, New York. viii + 274 pp., illus. U.S.$54.50.

The fauna of Kiskunsag National Park, volume 1. 1986. Edited by S. Mahunka. Kultura, Budapest. 512 pp., illus. U.S.$48.

The freshwater Mollusca of northern Africa: distribution, biogeography, and palaeoecology. 1984. By Dirk van Damme. Junk (distributed by Kluwer, Hingham, Massachusetts). xiv + 164 pp., illus. U.S.$55.

†**Fur seals: maternal strategies on land and at sea.** 1986. Edited by Roger L. Gentry and Gerald L. Kooyman. Princeton University Press, Princeton. c290 pp., illus. Cloth U.S.$40; paper U.S.$14.50.

†**Guide to mammals of the plains states.** 1986. By J. Knox Jones, Jr., David M. Armstrong, and Jerry R. Choate. University of Nebraska Press, Lincoln. xvii + 371 pp., illus. Cloth U.S.$31.50; paper U.S.$15.95.

Gulls and plovers: the ecology and behaviour of mixed-species feeding groups. 1985. By C. J. Barnard and D. B. A. Thompson. Columbia University Press, New York. xii + 302 pp., illus. U.S.$30.

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Insect life: a field entomology manual for the amateur naturalist. 1985. By Ross H. Arnett, Jr., and Richard L. Jaques, Jr. Prentice-Hall, Englewood Cliffs, New Jersey. xii + 354 pp., illus. U.S.$14.95.

*__An introduction to ethology.__ 1985. By P. J. B. Slater. Cambridge University Press, New York. vii + 195 pp., illus. Cloth U.S.$39.50; paper U.S.$12.95.

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***Mammals of the Carolinas, Virginia, and Maryland.** 1985. By W. D. Webster, J. E. Parnell, and W. L. Biggs, Jr. University of North Carolina Press, Chapel Hill. 256 pp., illus. U.S.$16.95.

Neurobiology of arachnids. 1985. Edited by Friedrich G. Barth. Springer-Verlag, New York. xii + 385 pp., illus. U.S.$69.50

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†**Safety in bear country: a reference manual.** 1985. By M. Bromley. Northwest Territories Renewable Resources, Yellowknife. vi + 83 pp., illus. + 12 appendices.

The spider infraorder Mygalomorphae (Araneae): cladistics and systematics. 1985. By Robert J. Raven. Bulletin volume 182, article 1. American Museum of Natural History, New York. 180 pp., illus. U.S.$13.

Toxicity of pesticides to fish, volumes I and II. 1986. By A. S. Murty. CRC Press, Boca Raton, Florida. 192 pp. and 160 pp. U.S.$73.50 and U.S.$60.50. in the U.S.A.; U.S.$84.50 and U.S.$69.50 elsewhere.

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***Wild horses of the great basin: social competition and population size.** 1986. By Joel Berger. University of Chicago Press, Chicago. xxi + 326 pp., illus. U.S.$24.95.

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†**Red pines on the ridge.** 1985. By Leon E. Pavlick. Braemar Books, Victoria. xi + 35 pp., illus. $12.95.

*The vascular plants of South Dakota.** 1985. By T. van Bruggen. Second edition. Iowa State University Press, Ames. 478 pp., illus. U.S.$28.95 + U.S.$1.50 postage.

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†**The vegetation and phytogeography of Sable Island, Nova Scotia.** 1985. By P. M.. Catling, B. Freedman, and Z. Lucas. Proceedings of the Nova Scotia Institute of Science Volume 34, Part 3/4, 1984. Nova Scotia Institute of Science, Halifax. 66 pp., illus. $10.

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*Wildflowers of the Canadian Rockies.** 1986. By George W. Scotter and Halle Flygare. Hurtig, Edmonton. xix + 170 pp., illus. $19.95.

Environment

Conservation of tidal marshes. 1986. By Franklin C. Dalber. Gage, Agincourt, Ontario. 368 pp., illus. $59.95.

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An environmental agenda for the future. 1985. By John H. Adams, et al. 1985. Island Press, Washington. viii + 155 pp. U.S.$5.95.

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In the rain forest: report from a strange, beautiful, imperiled world. 1984. By Catherine Caufield. University of Chicago Press, Chicago. xii + 306 pp. + map. U.S.$9.95.

*Keys to the fauna and flora of the Minas Basin.** 1984. Compiled by Joan E. C. Bromley and J. Sherman Bleakney. Acadia University Institute, Wolfville, Nova Scotia. xi + 336 pp., illus. $19.95 + $3 shipping.

†**Lake Gardsjon: an acid forest lake and its catchment.** 1985. Edited by F. Andersson and B. Olsson. Ecological Bulletins 37. Forlagstjansten, Stockholm. 336 pp., illus. U.S.$44.

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Mutagenicity testing in environmental pollution control. 1985. By F. K. Zimmermann and R. E. Taylor-Mayer. Halsted (Wiley), New York. 1985 pp., illus. U.S.$52.95.

†**Natural selection in the wild.** 1986. By John A. Endler. Princeton University Press, Princeton. xiii + 336 pp. Cloth U.S.$40; paper U.S.$13.95.

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The discovery of the world: maps of the earth and the cosmos. 1985. By Elizabeth Hale. University of Chicago Press, Chicago. 88 pp., illus. Cloth U.S.$60; paper U.S.$25.

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A field guide to personal computers for bird watchers and other naturalists. 1986. By Edward M. Mair. Phalarope (Prentice-Hall, Englewood Cliffs, New Jersey). 176 pp. Cloth U.S.$16.95; paper U.S.$8.95.

A field manual for the amateur geologist: tools and activities for exploring our planet. 1986. By Alan M. Cvancara. Phalarope (Prentice-Hall, Englewood Cliffs, New Jersey). 196 pp., illus. Cloth U.S.$22.95; paper U.S.$12.95.

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Index to Volume 100

Compiled by W. Harvey Beck

Index to Book Reviews

Botany

Environment

Miscellaneous

Zoology

Advice to Contributors

Content

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TABLE OF CONTENTS *(concluded)*

Mailing date of the previous issue (volume 100, number 3): 31 December 1986

THE CANADIAN FIELD-NATURALIST Volume 100, Number 4 1986

Articles

Notes

concluded on inside back cover

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